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P.A. Boross and M.H. Mitchell

Petawawa National Forestry Institute • Information Report PI-X-106

Bibliographie : 1988-1990

P.A. Boross et M.H. Mitchell

Institut forestier national de Petawawa • Rapport d'information PI-X-106F

Forestry Canada Forêts Canada

Canada

PETAWAWA NATIONAL FORESTRY INSTITUTE

In common with the rest of Forestry Canada, the Petawawa National Forestry Institute has as its objective the promotion of better management and wiser use of Canada's forest resource to the economic and social benefit of all Canadians. Objectives of program activities carried out at the Institute support this goal through discovery, development, demonstration, implementation, and transfer of innovations. Because it is a national institute, particular emphasis is placed on problems that transcend regional boundaries or that require special expertise and equipment that cannot be duplicated in Forestry Canada regional establishments. Such research is often performed in close cooperation with staff of the regional centres, provincial forest services, and the forest industry.

Research initiatives and technical services at the Institute encompass five major activities:

FOREST GENETICS AND BIOTECHNOLOGY — Integrates projects in tree genetics, soil microbiology, micropropagation, molecular genetics, meteorology, and seed research. It also includes the client services and seed bank operations of the National Tree Seed Centre, a long-standing program with extensive international affiliations.

FOREST MANAGEMENT SYSTEMS — This program integrates projects in fire, remote sensing, modelling, growth and yield, and forest pest management to provide research and development for the formulation and demonstration of forest management systems.

NATIONAL FOREST RESOURCE STATISTICS — Provides biological, technical, and socioeconomic information on Canada's forest-based resources. The program involves progressive development of databases and establishment of new databases and software in support of policy development in forestry. The Forest Inventory Program collates information on the forest resource at a national level, maintains the Canadian Forest Resources Data System, and prepares the national forest inventory.

COMMUNICATIONS — Integrates activities of the library, public awareness, information, and editing and publications projects. The Institute is visited by more than 20 000 people every year. There is a Visitor Centre for the public, self-guided tours, and an extensive education project. The national repository of all scientific and technical publications of the Forestry Canada and the principal Forestry Canada publications distribution centre are both located at PNFI.

THE RESEARCH FOREST — Besides natural stands manipulated in a variety of ways for silvicultural research, the 100 km^2 Petawawa Forest contains extensive areas of plantations dating back six decades. Research plantations are a source of growth and yield data derived from cultural experiments, and they are becoming valuable for pedigreed genetic materials for micropropagation and molecular genetics studies. The forest also offers opportunities for short- and long-term testing of forest management strategies.

INSTITUT FORESTIER NATIONAL DE PETAWAWA

Le mandat de l'Institut forestier national de Petawawa (IFNP), comme celui des autres établissements de Forêts Canada, est de promouvoir une meilleure gestion et une utilisation plus rationnelle des ressources forestières du Canada, pour le bien économique et social de tous les Canadiens. Les objectifs des programmes menés à l'Institut appuient ce mandat à travers la découverte, le développement, la démonstration, l'application et le transfert des innovations. En tant qu'institut national, il doit s'attacher à des problèmes qui débordent le cadre régional ou qui nécessitent des compétences particulières de même qu'un équipement non disponible aux installations régionales de Forêts Canada. La plupart du temps, les recherches sont effectuées en étroite collaboration avec le personnel des centres régionaux, des services forestiers des provinces et de l'industrie forestière.

Les travaux de recherche et les services techniques de l'Institut sont regroupés autour de cinq principales activités:

GÉNÉTIQUE FORESTIÈRE ET BIOTECHNOLOGIE — Ce programme encadre des études sur la génétique forestière, la microbiologie, la micropropagation, la génétique moléculaire et la recherche sur les semences. Il comprend également les services à la clientèle et la banque de semences du Centre national de semences forestières. Lié à plusieurs organismes internationaux, ce centre existe depuis longtemps.

SYSTÈMES D'AMÉNAGEMENT FORESTIER — Ce programme intègre en recherche et développement des opérations concernant les incendies de forêt, la télédétection, la météorologie, la modélisation, la croissance, la récolte et le relevé des insectes et des maladies des arbres (RIMA). Il permet ainsi l'élaboration et la démonstration de systèmes d'aménagement forestier.

STATISTIQUES NATIONALES SUR LES RESSOURCES FORESTIÈRES — Ce programme fournit les renseignements biologiques, techniques et socio-économiques sur les ressources forestières du Canada. Il vise le développement des bases de données et l'établissement de nouveaux logiciels et bases de données pour aider à l'élaboration des politiques forestières. Le Programme d'inventaire forestier recueille l'information sur les forêts au niveau national, maintient le Système sur les ressources forestières canadiennes et prépare l'inventaire des forêts du Canada.

COMMUNICATIONS — Ce programme regroupe les services offerts par la bibliothèque, les travaux touchant la sensibilisation du public, les renseignements, la rédaction-révision et les publications. L'Institut reçoit plus de 20 000 visiteurs chaque année. Le Centre d'accueil, des visites autoguidées et un programme éducatif complet sont ouverts à tous. C'est à l'IFNP que l'on trouve l'entrepôt et le centre de distribution national de toutes les publications scientifiques de Forêts Canada.

LA FORÊT EXPÉRIMENTALE — Outre des peuplements naturels où l'on applique divers traitements dans le cadre des plans de recherche en sylviculture, la Forêt de Petawawa, mesurant 100 km^2, comprend de vastes superficies de plantations âgées de plus de 60 ans. Les plantations expérimentales livrent des données sur la croissance et la récolte à la suite des expériences de culture. Elles fournissent aussi du matériel génétique dont le lignage est répertorié et qui se révèlent de plus en plus utiles pour les études sur la micropropagation et la génétique moléculaire. C'est un lieu par excellence pour mettre à l'essai des stratégies d'aménagement forestier à court et à long termes.

BIBLIOGRAPHY/BIBLIOGRAPHIE
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P.A. Boross and/et M.H. Mitchell

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PREFACE

This Bibliography is the third in the series of *Bibliography/Liste des publications*. It contains all the scientific and technical publications in the years of 1988, 1989, and 1990 in a similar format with annotations.

The items in the chapter "List of publications" are numbered in alphabetical order of the author names. All the other index lists refer to the item numbers in this chapter, instead of page numbers.

Most of these publications are indexed by Forestry Abstracts. Title abbreviations follow the format of *Serial Sources for the BIOSIS Previews Data Base*, 1989 (BioSciences Information Service, Philadelphia, Pa., U.S.A.). The species/key word index is derived from the *CAB Thesaurus, C.A.B. International*, 1988.

The publications here described are available, in general free of charge, by writing to the following address:

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National Publications Distribution Centre
Chalk River, Ontario
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AVANT-PROPOS

La présente bibliographie est la troisième de la série *Bibliography/Liste des publications*. Elle comprend toutes les publications scientifiques ou techniques avec des annotations et couvre les années 1988, 1989 et 1990. Le mode de présentation est similaire à ceux des précédents. Le chapitre intitulé «Liste des publications» est organisé dans l'ordre alphabétique selon les noms d'auteurs. Tous les autres index réfèrent toujours aux numéros dans ce chapitre, au lieu des numéros de pages.

La plupart de ces documents sont déjà répertoriés dans la revue Forestry Abstracts. Les titres des périodiques sont abrégés selon *Serial Sources for the Biosis Previews Data Base*, 1989 (BioSciences Information Service, Philadelphie, Pa., U.S.A.). L'index des espèces et des mots clés est tiré du *Thésaurus CAB, C.A.B. International*, 1988.

Les publications énumérées dans le présent sont à la disposition de tous les intéressés, en général gratis. Il suffit d'en faire une demande à l'adresse suivante :

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PUBLICATIONS OF THE PETAWAWA NATIONAL FORESTRY INSTITUTE/

PUBLICATIONS DE L'INSTITUT FORESTIER NATIONAL DE PETAWAWA

1. **Aldred, A.H.; Alemdag, I.S. 1988. Guidelines for forest biomass inventory. PI-X-77.**

The manual describes procedures for including forest biomass assessment in forest inventory. The procedures cover the collection of data in the field, laboratory analysis, development of single-tree biomass equations, and application of the equations to both current and proposed new inventories.

2. **Aldred, A.H.; Alemdag, I.S. 1989. Lignes directrices pour l'inventaire de la biomasse forestière. PI-X-77F.**

Le manuel décrit des méthodes qui permettent d'inclure une évaluation de la biomasse forestière dans un inventaire des forêts. Ces méthodes englobent la prise de données sur place, l'analyse en laboratoire, l'élaboration d'équations pour la biomasse d'arbres individuels et l'application des équations à de nouveaux inventaires en cours ou envisagés.

3. **Alemdag, I.S. 1988. A ratio method for calculating stem volume to variable merchantable limits, and associated taper equations. For. Chron. 64:18-26.**

One method for estimating the volume of the merchantable portion of a tree stem is the volume ratio method. In this study the ratio used with this method was derived from another ratio expressed as ground-to-limit volume to total stem volume. Because of the latter ratio's strong correlation with the ratio of merchantable top diameter/breast height diameter and merchantable height/total tree height, several mathematical models were formed employing these variables for its estimation for red pine (*Pinus resinosa* Ait.) and sugar maple (*Acer saccharum* Marsh.). Among the models that were tested, the best for each variable was chosen by assessing its adequacy by the statistical measures of fit index and standard error of estimate. When checked against an independent set of data, these best models performed satisfactorily, with small overall biases. Furthermore, taper equations were derived from these ground-to-limit volume ratio equations.

Il est possible d'estimer le volume de la partie marchande d'une tige par rapport au volume de l'arbre. Nous avons employé dans la présente étude un rapport tiré d'un autre rapport exprimé sous la forme suivante : volume du collet à la limite marchande/volume total de la tige. Comme il existe une forte corrélation entre ce dernier rapport et les rapports diamètre au fin bout de la tige/diamètre à hauteur de poitrine et hauteur marchande/hauteur totale de l'arbre, plusieurs modèles mathématiques ont été construits à l'aide de ces variables pour l'estimation du rapport pour le pin rouge (*Pinus resinosa* Ait.) et l'érable à sucre (*Acer saccharum* Marsh.). Nous avons contrôlé ces modèles et déterminé celui qui était le meilleur pour chaque variable d'après le coefficient d'ajustement et l'écart-type d'estimation. Les modèles retenus, appliqués à un ensemble indépendant de données, ont donné des résultats satisfaisants, avec un faible biais global. De plus, des équations de défilement ont été tirées de ces équations du rapport volume du collet à la limite marchande/volume total de la tige.

4. **Alemdag, I.S. 1988. Site index equations for white spruce in the Northwest Territories, Canada. For. Ecol. Manage. 23:61-71.**

A new, two-stage method of developing site index equations and curves from stem analysis data is described. The linear relationship between site index and height for a given age class is confirmed. Regression lines are calculated at 10-year intervals and the relationship between the intercepts, $a0$, and the slopes, $a1$, of these lines, and age are established. From these, the final form of the site index equation could be derived and its coefficients established from estimates of height calculated at 10-year intervals from the individual tree height/age curves by conventional regression analysis. This site index equation is accurate except for combinations of high site index and high age.

5. **Alemdag, I.S. 1990. Coefficients de calcul de volume marchand et équations du défilement chez les essences commerciales de l'Ontario. Rapports techniques de l'IFNP, n° 1.**

6. **Alemdag, I.S. 1990. Merchantable volume conversion factors and taper equations for commercial tree species of Ontario. PNFI Technical Reports No. 1.**

7. **Althen, F.W. von; Stiell, W.M. 1990. A red pine case history: Development of the Rockland plantation from 1914 to 1986. For. Chron. 66:606-610**

Growth data are presented for a 72-year-old plantation of red pine (*Pinus resinosa* Ait.) at Rockland, Ontario, part of which was thinned four times between 1938 and 1972 and part of which was left unthinned. Height growth in both parts ceased between stand ages 67 and 72 years. During the same 5-year period, gross periodic increment was 551 ft^3/ac (38.6 m^3/ha) in the thinned stand while in the unthinned stand mortality exceeded gross periodic increment by 187 ft^3/ac (13.1 m^3/ha).

Ce rapport présente des données sur la croissance d'une plantation de pins rouges (*Pinus resinosa* Ait.) de 72 ans située à Rockland, en Ontario; une partie de cette plantation a été éclaircie à quatre reprises de 1938 à 1972 et l'autre partie est restée intouchée. L'accroissement en hauteur s'est interrompu dans les deux parties entre l'âge de 67 et de 72 ans. Pendant cette même période de 5 ans, l'accroissement périodique brut était de 36,8 m^3/ha (551 pi^3/acre) dans le peuplement éclairci tandis que la mortalité dépassait l'accroissement périodique brut de 13,1 m^3/ha (187 pi^3/acre) dans le peuplement non éclairci.

8. **Anderkas, P. von; Klimaszewska, K.; Bonga, J.M. 1990. Diploid and haploid embryogenesis in *Larix leptolepis, L. decidua*, and their reciprocal hybrids. Can. J. For. Res. 20:9-14.**

Diploid and haploid embryogenesis was induced in two *Larix* species (*L. decidua* and *L. leptolepis*) and their reciprocal hybrids. Diploid embryogenic tissue was initiated in immature zygotic embryos isolated with the micropylar half of the megagametophyte left attached. These were placed either on modified LM or MSG medium supplemented with the growth regulators 2,4-D and 6-benzyladenine. MSG medium was solidified with either gellan gum or agar. There was no appreciable difference in response between the two. Haploid embryogenesis was induced in isolated megagametophytes placed on modified LM medium supplemented with 2,4-D and 6-benzyladenine. Diploid embryogenic tissue was subcultured on medium with growth regulators, but haploid embryogenic tissue grew well on medium without growth regulators. There were few morphological differences between the diploid and haploid embryogenic tissue. In all species and hybrids, haploid cultures contained more coenocytic long cells. Binucleate cells were most common, but tetranucleate and octanucleate cells were also present. Haploid cultures showed poorer organization than the diploid ones, with only a few cultures having well-developed embryoids. Haploid tissue originated from expanded cells of the megagametophyte. Diploid tissue originated from the suspensor region of the zygotic embryo; it proliferated from isolated clusters of meristematic cells in early embryoids. Diploid and haploid cultures differed not only from the outset, but also in the mature embryoids they produced.

L'embryogénèse diploïde et haploïde a été induite chez deux espèces de *Larix* (*L. decidua* et *L. leptolepis*) et leurs hybrides réciproques. Le tissu embryogène diploïde a été initié à partir d'embryons zygotiques immatures isolés avec la moitié du micropyle du mégagamétophyte attachée. Ces embryons furent placés sur les milieux LM ou MSG modifiés et enrichis avec les hormones de croissance 2,4-D et 6-benzyladenine. Le milieu MSG a été solidifié avec de la gomme gellan ou avec de l'agar. Il n'y avait pas de réponse significativement différente selon l'agent solidifiant utilisé. L'embryogénèse haploïde a été induite à partir de mégagamétophytes isolés et placés sur le milieu LM modifié et enrichi avec du 2,4-D et du 6-benzyladenine. Le tissu embryogène diploïde croissait bien sur un milieu sans hormones de croissance. Il y avait quelques différences morphologiques entre les tissus embryogènes diploïde et haploïde. Chez tous les espèces et les hybrides, les cultures haploïdes contenaient plus de longues

cellules coenocytiques. Les cellules à deux noyaux étaient les plus fréquentes, mais il y avait aussi des cellules à quatre et huit noyaux. Les cultures haploïdes avaient une moins bonne organisation que les cultures diploïdes, avec seulement quelques cultures possédant des embryoïdes bien développés. Le tissu haploïde originait des cellules élargies du mégagamétophyte. Le tissu diploïde originait de la région du suspenseur de l'embryon zygotique. Il se développait à partir de groupes isolés de cellules méristématiques pour former de jeunes embryoïdes. Les cultures haploïdes et diploïdes différaient non seulement à partir du commencement mais aussi par les embroïdes matures qu'ils produisaient.

9. **Ballantyne, B.A.; Mitchell, M.H., comp. 1989. Bibliography/Liste des publications 1986-1987. PI-X-87E/F.**

10. **Baskerville, G.; Moore, T. 1988. Forest information systems that really work. For. Chron. 64:136-140.**

Forest information systems are an essential element in the design and implementation of forest management, yet there are a lot of information systems that do not work well. The task of building usable information systems has been fragmented and underestimated and, with the tendency to throw computer technology at a problem, it is still being underestimated. To get information systems that really work, the forestry community must spend time and effort in discovering the information needs across several decision levels.

En foresterie, les systèmes informatiques constituent un élément essentiel de la conception et de la mise en œuvre de l'aménagement forestier; cependant, nombreux sont les systèmes qui ne fonctionnent pas bien. La construction de systèmes informatiques utilisables est une tâche qui a été fragmentée et sous-estimée; avec la tendance actuelle de se servir des techniques informatiques pour résoudre un problème à la fois, cette situation tend à perdurer. Pour en venir à des systèmes informatiques qui fonctionnent réellement, les milieux qui s'occupent de foresterie doivent consacrer du temps et des efforts à découvrir les besoins d'information qui existent à tous les niveaux de la prise de décisions.

11. **Bird, G.A.; Chatarpaul, L. 1988. Effect of forest harvest on decomposition and colonization of maple leaf litter by soil microarthropods. Can. J. Soil Sci. 68:29-40.**

The effect of whole-tree and conventional forest harvest on sugar maple leaf litter decomposition and the colonization of litter bags by soil microarthropods was investigated in a mixed conifer/hardwood forest on the Canadian Shield for 2 yr, beginning 17 mo after forest harvesting. Decomposition of leaves in litter bags was significantly greater ($P << 0.05$) on harvested plots than on the uncut plot (U), and was greater on the whole-tree harvest plot (W) than on the conventionally harvested plot (C). The increase in nitrogen (N) concentration of the litter over the 2-yr study was greater ($P << 0.05$) on the C than on the other plots and was in the order C>>W>>U. Colonization of leaf litter by soil microarthropods was greater ($P << 0.05$) on the U than on harvested plots, and was greater ($P << 0.05$) on the C than on the W plot. Thus, soil microarthropods did not appear to be responsible for the faster decomposition on harvested plots compared to the uncut plot, nor were differences in soil temperatures or moisture content among plots responsible for the faster rates of decay. More rapid decay on harvested plots suggests that harvesting increased the availability of nutrients contained in the forest floor. This may result in a loss of both nutrients and long-term productivity, especially with whole-tree harvesting, unless mechanisms are in place to conserve nutrients.

On a étudié les effets de l'exploitation par arbres entiers et de l'exploitation traditionnelle sur la décomposition de la litière de feuilles d'érable et la colonisation de sacs de litière par les micro-arthropodes du sol dans une forêt mixte de résineux et de feuillus du Bouclier canadien pendant deux ans, en commençant dix-sept mois après l'abattage des arbres. La décomposition des feuilles en sacs de litière était significativement plus grande ($P << 0,05$) dans les parcelles exploitées que dans les parcelles

intactes (U), et elle était plus grande dans les parcelles soumises à l'exploitation par arbres entiers (W) que dans les parcelles soumises au mode d'exploitation traditionnel (C). L'augmentation de la teneur en azote (N) de la litière au cours des deux années de l'étude était plus grande (P << 0,05) dans les parcelles C que dans les autres parcelles. Les trois groupes se classaient dans l'ordre comme suit : C>>W>>U. La colonisation de la litière de feuilles par les micro-arthropodes du sol était plus importante (P << 0,05) dans les parcelles U que dans les parcelles exploitées et elle était également plus importante (P,<<0,05) dans les parcelles C que dans les parcelles W. Ainsi, il ne semble pas que les micro-arthropodes n'aient été responsables de l'accélération de la décomposition dans les parcelles exploitées, comparativement aux parcelles intactes, ni que les différences observées dans les températures et la teneur en humidité du sol entre les parcelles n'aient été à l'origine d'un taux de décomposition plus rapide. Cette décomposition plus rapide observée dans les parcelles exploitées donne à penser que la récolte des arbres a provoqué une hausse de la disponibilité des matières nutritives contenues dans le sol. Ceci pourrait avoir le double effet d'abaisser la teneur en matières nutritives et la productivité à long terme, en particulier lorsqu'on procède à l'exploitation par arbres entiers, à moins qu'il n'existe des mécanismes permettant la conservation des matières nutritives.

12. Blake, T.J.; Yeatman, C.W. 1989. Water relations, gas exchange, and early growth rates of outcrossed and selfed *Pinus banksiana* families. Can. J. Bot. 67:1618-1623.

Seedlings of six outcrossed jack pine (*Pinus banksiana* Lamb.) families from a diallel cross of jack pine were mainly larger than those of three selfed families at the time they were transplanted to the field in Ontario. Outcrossed families also exhibited a greater absolute and relative (percent) growth in total dry matter at the end of the first growing season. Outcrossed families exhibited a higher net photosynthesis, a lower transpiration rate, and a higher water use efficiency on hot, but not mild, days in mid-August. Stomatal conductance, transpiration rate, and net photosynthesis were greater in outcrossed families in September. There were significant, positive correlations between stomatal conductance, transpiration rate, and shoot and root growth in August and September. The results suggest that maintenance of a higher stomatal conductance and net photosynthesis until late in the growing season may contribute to the faster growth rates observed in outcrossed families.

De jeunes plants de six familles de *Pinus banksiana* Lamb. issues d'un croisement diallèle étaient plus gros que ceux de trois familles autofécondées au moment de leur transplantation au champ en Ontario. Les familles hétérofécondées montraient aussi une croissance absolue et relative plus élevée (pourcentage) en masse sèche totale à la fin de la première saison de croissance. Elles avaient une photosynthèse apparente plus élevée, un taux de transpiration plus bas et une efficacité d'utilisation de l'eau plus grande par jours chauds mais non par jours doux, à la mi-août. La conductance stomatique, le taux de transpiration, et la photosynthèse étaient plus élevés chez les familles hétérofécondées, en septembre. Des corrélations positives significatives furent établies entre la conductance stomatique, le taux de transpiration, et la croissance de la racine et de la tige, en août et septembre. Les résultats suggèrent que le maintien d'une conductance stomatique et d'une photosynthèse apparente plus élevée tard durant la saison de croissance peut contribuer aux vitesses plus rapides de croissance observées dans les familles hétérofécondées.

13. Bonnor, G.M.; Magnussen, S. 1988. Predicting stem diameter distributions from growth probability equations. Pages 192-200 *in* Ek, A.R. et al., eds. Proc. IUFRO Conf. Forest Growth Modelling and Prediction. Vol. 1. Minneapolis, Minn. Soc. Am. Foresters Publication SAF 87.12.

One method of predicting stem diameter distributions for unevenaged forest stands is to develop empirical growth probability matrices based on past growth, and apply them to current diameter distributions. The purpose of this paper is to determine if this matrix approach can be improved by deriving growth probability values from equations in which growth probability is functionally related to stem diameter.

Using permanent sample plot data from an uneven-aged, mixed forest in Eastern Ontario, the relationships between five-year growth probability and 1 cm stem diameter classes was explored. It was found that such relationships could be expressed by simple first- or second-degree polynomials, or by constants. Growth probability equations were calculated by major species groups, and the values derived from them were used to project stem frequencies and volumes from 1985 to 1995. While the absence of long-term basic data prevented an assessment of accuracy, the method proved to be feasible and yield good results.

14. Bousquet, J.; Cheliak, W.M.; Lalonde, M. 1988. Allozyme variation within and among mature populations of speckled alder (*Alnus rugosa*) and relationships with green alder (*A. crispa*). Amer. J. Bot. 75:1678-1686.

Vegetative tissues from 14 sexually mature populations of speckled alder (*Alnus rugosa* (Du Roi) Sprengel) in Québec were analyzed for electrophoretically demonstrable variation in nine enzymes encoding a total of 15 loci. Speckled alder demonstrated a diploid-like expression for all polymorphic loci investigated. Populations were in Hardy-Weinberg equilibrium for the nine polymorphic loci observed. The total expected heterozygosity was 0.173. Analysis of fixation indices indicated a slight deficiency of heterozygotes, relative to panmictic expectations. This was likely due to weak population differentiation, which did not follow any particular geographical trend. Qualitative estimates of interpopulation rates of gene flow were high, and in good agreement with the small pair-wise population genetic distances and among-population fixation index. Levels of genetic diversity and partition of this diversity were similar to previous observations obtained with the sympatric species *A. crispa* (Ait.) Pursh. However, no phenomena of interspecific hybridization were noted. The average genetic distance between these two alder species was large, with a value of 0.4, emphasizing the different ecological niches colonized by each of the two species. The estimate of divergence time between these two taxa was two million years. It is in agreement with the hypothesis of repetitive spatial isolation of each species in ice-free refugia during the Pleistocene, thus promoting their reproductive isolation. The interspecific divergence noted at the enzyme level allowed for the easy electrophoretic identification of each taxon.

15. Bousquet, J.; Cheliak, W.M.; Wang, J.; Lalonde, M. 1990. Genetic divergence and introgressive hybridization between *Alnus sinuata* and *A. crispa* (*Betulaceae*). Plant Syst. Evol. 170:107-124.

The actinorhizal genus *Alnus* contains numerous taxa that have been morphologically classified into different subgenera, species, and subspecies. The genetic divergence has been evaluated within subgenus *Alnobetula* between the parapatric taxa *Alnus sinuata* and *A. crispa*, using diversity of allozyme markers at 15 structural loci among 20 populations. Evidence for introgressive hybridization at the overlap of their ranges was noted in three populations. However, the width of the hybrid zone appeared tenuous. The average genetic distance derived from the comparisons of conspecific populations was much smaller than the interspecific distance (D=0.047). This allelic divergence was also paralleled with larger amounts of allelic and genotypic diversity within and among populations of *A. sinuata*, which are occupying a more heterogenous ecological niche. It is proposed that the repeated advances and retreats of the ice sheet during the Pleistocene may have promoted the divergence and allopatric evolution of these subspecies, and that secondary contact may have occurred repeatedly during the interglacial periods. The dynamic-equilibrium model would predict in such cases that narrow hybrid zones, formed at the contact of parapatric ranges, would impede gene exchange between parental taxa by selection against hybrids. The results obtained in this study seemed concordant with this hypothesis, as they were also in agreement with the existent taxonomical treatment of these taxa based on morphology.

16. **Boyle, T.J.B. 1990. Black spruce genetic research, Petawawa National Forestry Institute. Pages 21-25 *in* Rogers, D.L., ed. 1990. Proc. Ann. Meeting, Black spruce clonal forestry program. OMNR, Timmins, Ont.**

Recent progress in research on black spruce genetics at the Petawawa National Forestry Institute is described. This research covers topics such as clonal forestry, climate change, tree improvement strategy, and population genetics.

17. **Boyle, T.J.B.; Balatinecz, J.J.; McCaw, P.M. 1988. Genetic control of some wood properties in black spruce. Page 198 *in* Morgenstern, E.K.; Boyle, T.J.B., eds. Proc. 21st Meeting CTIA Part II, Truro, N.S.**

Wood properties were assessed on 15-year-old trees from a complete 7 x 7 diallel cross of black spruce (*Picea mariana* [Mill.] B.S.P.), planted in four locations at Petawawa National Forestry Institute. The relative magnitude of variance components due to general combining ability (gca) and specific combining ability (sca) give an indication of the importance of additive, compared with non-additive, genetic variation. This, in turn, determines the suitability of a purely additive strategy for genetic improvement of the trait.

18. **Boyle, T.J.B.; Coles, J.F.; Hood, J.V. 1988. A pilot cooperative accelerated tree improvement programme. Page 138 *in* Morgenstern, E.K.; Boyle, T.J.B., eds. Proc. 21st Meeting CTIA Part II, Truro, N.S.**

Black spruce (*Picea mariana* [Mill.] B.S.P.) is the major commercial species in the Northern Region of Ontario's Ministry of Natural Resources, with a projected annual planting stock requirement of 50 million plants. To meet this requirement, operational tree improvement activities have recently been initiated involving programmes of plus-tree selection, testing, and seed orchard establishment, together with some vegetative propagation of seedlings from plus-tree selections.

19. **Boyle, T.; Liengsiri, C.; Piewluang, C. 1990. Genetic structure of black spruce on two contrasting sites. Heredity 65:393-399.**

Several hundred dominant and co-dominant individuals in two populations of black spruce, located within 2 km of each other and representing upland and lowland site types, were sampled and mapped. Multilocus isozyme genotypes were determined and the genetic organization of the two populations examined by means of nearest-neighbour analysis and spatial autocorrelation of alleles. On the upland site type, population density was much higher and variation in age considerably less than on the lowland site type, which was interpreted as evidence for fire origin in the former. On the upland site, the mature trees were more inbred, possibly due to the conditions under which regeneration occurred and because of weak selective pressure. On the lowland site, clustering of similar genotypes was detectable on a local scale but the mature trees were not inbred. The two populations were very similar in terms of allozyme frequencies.

20. **Boyle, T.J.B.; Magnussen, S.; Nieman, T.C.; Yeatman, C.W. 1989. Forest genetics, Petawawa National Forestry Institute 1987-89. Pages 85-90 *in* Magnussen, S.; Boyle, T.J.B., eds. Proc. 22nd Meeting CTIA Part I, Edmonton, Alta.**

In preparation for a peer review held in February 1989, the project was restructured and its objectives redefined to place greater emphasis on investigations of the physiological basis of genetic variation and modeling. Two new studies were initiated, on the genetics of climate change and silcivultural implications of genetic improvement. In support of these changes, improved facilities will be

established incorporating controlled-environment rooms and a state-of-the-art greenhouse. Facilities for rooting of cuttings have also been added in the past year. Interim-phase plans were formulated for ASEAN-Canada Forest Tree Seed Centre Project in Thailand.

21. **Boyle, T.J.B.; Nieman, T.C.; Magnussen, S.; Veen, J. 1989. Species, provenance, and progeny tests of the genus *Larix* by the Petawawa National Forestry Institute. PI-X-94.**

Information is presented on all experiments established by the Tree Genetics and Breeding Project of Forestry Canada's Petawawa National Forestry Institute of the genus *Larix* over the last 65 years. A total of 128 experiments and 906 seedlots are listed. The most valuable and well-designed experiments are discussed in detail and recommendations are presented for the use of native and exotic larch species in eastern Canada.

22. **Boyle, T.J.B.; Nieman, T.C.; Magnussen, S.; Veen, J. 1990. Essais d'espèces et tests de provenance et de descendance du genre *Larix* à l'Institut forestier national de Petawawa. PI-X-94F.**

Les auteurs décrivent toutes les expériences menées sur le genre *Larix* par le groupe du Programme de l'amélioration génétique des arbres à l'Institut forestier national de Petawawa de Forêts Canada. Au cours de 65 ans jusqu'ici écoulés, on compte en tout 125 expériences et 906 lots de semences. Les expériences les plus importantes et les mieux planifiées sont décrites en détail, accompagnées de recommandations quant à l'emploi des mélèzes indigènes ou exotiques dans l'est du Canada.

23. **Boyle, T.J.B.; Yeh, F.C. 1988. Within-population genetic variation-implications for selection and breeding. Pages 20-42 *in* Boyle, T.J.B., ed. Proc. 21st Meeting of the Canadian Tree Improvement Association, Truro, N.S.**

Methods for measuring genetic variation within populations are described and results summarized from studies on Canadian forest trees. Most species demonstrate high levels of variation, with generally more than 90% of the total variation contained within populations. The implications of variation in allele frequencies and mating system parameters are discussed in relation to selection, breeding, and conservation. It is argued that knowledge of within-population variation is required, not only for efficient selection in natural populations, but also in order to design optimum breeding and production populations and tree improvement strategies. Some major gaps in current knowledge are also listed.

On décrit les méthodes pour mesurer la variation génétique à l'intérieur des populations, et on résume les résultats d'études effectuées sur des arbres forestiers du Canada. La plupart des espèces présentaient des variations considérables; généralement plus de 90 % de la variation totale se manifestait à l'intérieur des populations. On expose les répercussions de la variation de la fréquence des allèles et des paramètres du système de croisement en relation avec la sélection, l'amélioration génétique et la conservation. Il faut connaître les variations au sein des populations, non seulement pour la sélection efficace chez les populations naturelles, mais aussi pour mettre au point des stratégies optimales d'amélioration des arbres ainsi que des populations optimales de production et d'amélioration génétique. On énumère également certaines lacunes dans nos connaissances actuelles.

24. **Brand, D.G. 1988. A systematic approach to assess forest regeneration. For. Chron. 64:414-420.**

As the area of second-growth and planted forest increases, successful management will require increasingly efficient methods of data collection and use. Developing plantation assessment systems requires the definition of what information is useful in decision-making, how best to collect that information, and how best to present it to the decision-maker or forester. In this paper a system is described that processes field survey data collected by a portable datalogger through a relay of

software programs. The programs provide data summary, free-growing projection, application of a new spatial pattern statistic, and use of a Geographic Information System (GIS) for map production. The information generated will allow a forester to define whether the area needs brush control or fill planting, and whether those problems are localized (i.e. in brushy patches, or unstocked holes in the plantation) or spread through the entire area surveyed. The systematic collection and processing of survey data can also lead to the development of whole-forest silviculture planning models, comparing the estimated opportunities for growth and yield enhancement on a diversity of regenerating areas with economic criteria.

À mesure que la superficie des jeunes peuplements forestiers et des forêts plantées augmentera, il faudra employer des méthodes de plus en plus efficaces de collecte et d'utilisation de données pour garantir leur bonne gestion. Il faut mettre au point des systèmes efficaces d'aide à la décision, en particulier au stade de la régénération, pour s'assurer que les dépenses engagées pour la gestion forestière se traduisent par des rendements optimaux dans les peuplements de croissance libre aux sites les plus productifs. Le présent rapport décrit un système de traitement de l'information recueillie sur le terrain au moyen d'un enregistreur de données portable par l'intermédiaire d'un ensemble de logiciels. Ces derniers permettent de résumer l'information, de faire des projections des peuplements en croissance libre, d'établir des statistiques sur la configuration spatiale et d'utiliser un système d'information géographique (SIG) pour l'établissement de cartes. L'analyse dans les meilleurs délais de la régénération des forêts sur les plans de la productivité et de la configuration spatiale peut permettre l'élaboration de modèles de planification sylvicole à l'échelle de forêts entières et la prise en compte de critères économiques dans l'étude des possibilités anticipées d'amélioration de la croissance et des rendements.

25. **Brand, D.G. 1989. Managing for successful reforestation programs. Can. For. Ind., March 1989: 30-35.**

The type of reforestation system that we have developed in Canada is extensive in nature. That is, programs are developed and allocated at the whole-forest level. In most provinces, however, performance criteria are applied at the stand level, tending to maintain diffuse or extensive silviculture programs. Effective planning requires freedom to move expenditures to treatments that alleviate wood supply problems. In most cases planning and financial analysis of silviculture will move more work to better quality or better located sites, and result in more intensive management of a smaller land base.

26. **Brand, D.G. 1990. Advances in Canadian forest research: an introduction. Can. J. For. Res. 20:373-374.**

27. **Brand, D.G. 1990. Les facteurs du milieu qui interviennent dans le développement des plants sur le terrain. Colloque sur la mise en terre des plants forestiers, Ministère de l'Énergie et des Ressources (Forêts) du Québec. Sainte-Foy, Qc.**

28. **Brand, D.G. 1990. Forest stand development: concepts and concerns. Proc. of a Workshop, Thunder Bay, Ontario, April 19-20, 1989. Pages 98-107 *in* A.J. Willcocks, et al., eds. Ontario Ministry of Natural Resources.**

An understanding of forest stand development is a precursor to meaningful growth and yield estimation. As the demand for information on pre-rotation age stands increases, the need for models of stand development will intensify. This paper discusses some basic concepts of forest stand development and delineates potential strategies for modelling those biological processes

29. **Brand, D.G. 1990. Growth analysis of responses by planted white pine and white spruce to changes in soil temperature, fertility, and brush competition. For. Ecol. Manage. 30:125-138.**

A factorial field experiment, located near Chalk River, Ontario, Canada, was used to test the effects of brush competition, fertility, and soil temperature on first and second-season growth of planted white pine and white spruce. Soil temperature, soil moisture tension, and photosynthetically active radiation were continuously monitored to quantify treatment effects. Foliar nutrition was assessed on nursery stock pre-planting and on current and previous foliage age classes after one growing-season. Measurement of biomass components and leaf surface area was carried out after one growing-season. Increasing soil temperature improved the net photosynthetic rate (P_n) of both species in the first growing-season. Relative growth rate (G_r) of both species was positively affected by the soil temperature treatments but, because of changes in carbon partitioning and foliage morphology, was not directly related to P_n. Fertilization and brush control treatments caused compensating adjustments in morphology and biomass allocation that did not affect G_r in the first season. In the second season, environmental conditions changed and brush competition increasingly influenced growth. Despite the changes in environmental conditions during the plantation establishment period, the ability of trees to successfully adjust to environmental stress increased from the first growing-season to the second.

30. **Brand, D.G.; Becker, A. 1989. A framework for integrating silviculture survey with data analysis, planning, and database update. Pages 35-39 *in* Proc. GIS '89, Vancouver, B.C. Reid-Collins/For. Can.**

Management of public forest land requires large information management systems to support decisions at the stand level, forest level, and even provincial level. These information systems currently include field surveys for stand level decision-making and forest inventory for whole forest or timber supply area analysis. Field survey data can be used to update inventory information, but there is currently limited ability of field staff to access the central information system to assist with work planning or map production. A prototype system, designed to automatically collect field data on plantation performance, analyze the data, send output files to the central GIS, and produce field maps with the GIS, is described. A field trial was conducted in the Squamish Forest District (Southwestern B.C.) with this system and an interface written with PAMAP software to allow district level map production. Future developments of these types of systems will allow much more effective use of field survey data and allow improvements in planning and work scheduling at the field level.

31. **Brand, D.G.; Flannigan, M.D.; Janas, P.S. 1988. Using datalogger systems for environmental monitoring in forest research: an overview and case study. PI-X-81.**

This is an introduction for forest researchers to the monitoring of environmental conditions with automatic dataloggers. The report discusses various aspects of the experimental design (definition of what, where, how, and when to measure), the technological design, and the management of environmental monitoring research programs. A case study of a large field installation with continuous monitoring of 92 sensors is used to demonstrate the design, operation, and management of data from a research project. Automatic data collection with environmental sensors increases the ability of forest researchers to quantify conditions and explain secondary influences on results. Care must be taken, however, in proper selection of variables to measures; choice of hardware, sensors, and peripherals; correct installation and system protection; and effective data management.

32. **Brand, D.G.; Flannigan, M.D.; Janas, P.S. 1989. Utilisation de consignateurs de données pour la surveillance environnementale en recherche forestière : vue d'ensemble et étude de cas. PI-X-81F.**

Il s'agit d'un guide d'initiation au processus de surveillance des conditions environnementales à l'aide de consignateurs de données automatiques qui s'adresse aux chercheurs forestiers. Le rapport aborde différents aspects du dispositif expérimental (quoi, où, comment et quand mesurer), du devis technique et de la gestion de programmes de recherche en surveillance environnementale. L'étude de cas d'une importante installation comportant la surveillance constante de 92 senseurs est utilisée pour démontrer les méthodes de conception, d'exploitation et de gestion des données dans le cadre d'un projet de recherche. La collecte automatique de données à l'aide de capteurs environnementaux accroît la capacité des chercheurs forestiers de quantifier les conditions et d'expliquer leurs effets secondaires sur les résultats. Il faut cependant bien choisir les variables à mesurer, le matériel, les senseurs et les périphériques et avoir une installation et un système de protection appropriés ainsi qu'une bonne gestion des données.

33. **Brand, D.G.; Janas, P.S. 1988. Growth and acclimation of planted white pine and white spruce seedlings in response to environmental conditions. Can. J. For. Res. 18:320-329.**

A factorial experiment was used to examine the effects of soil temperature, brush competition, and fertility on the postplanting growth and development of white spruce (*Picea glauca* (Moench) Voss) and white pine (*Pinus strobus* L.) on a clear-cut forest site at the Petawawa National Forestry Institute. Environmental monitoring was used to confirm that soil temperature treatments were effective and that the brush competition treatments caused significant (<F128M>a<F255D> = 0.0001) differences in photosynthetically active radiation at tree level. On the basis of foliar analysis, both fertilization and brush control improved nutrient availability to the planted trees. Owing to adequate, well-distributed precipitation, soil moisture tension was not greater than 0.6 bars (1 bar = 100 kPa) in any treatment during the growing season. Growth response by both species was dominantly controlled by the soil temperature factor. Fertility produced secondary benefits to white pine, and brush control had secondary benefits to white spruce. Examination of a developmental sequence of height growth, leaf length growth, basal area growth, and terminal bud mass indicated that soil temperature treatments were beneficial throughout the growing season, that brush control was important only in late season, and that fertilization had slight negative effects in early season but a positive effect by late season. Developmental features also indicated that soil temperature effects were manifested by reduced shoot and needle extension in the trees, competition effects by reduced availability of light, nutrients, and moisture, and fertilizer effects by increased foliar element concentrations.

Les auteurs ont fait appel à une expérience factorielle pour étudier les effets de la température du sol, de la compétition de la broussaille et de la fertilité sur l'accroissement et le développement ultérieurs de semis d'épinette blanche (*Picea glauca* (Moench) Voss) et de pin blanc (*Pinus strobus* L.) plantés dans un parterre de coupe rase de l'Institut forestier national de Petawawa. Le milieu a été surveillé pour s'assurer de l'efficacité des traitements de la température du sol et confirmer que les traitements contre la broussaille provoquaient des différences significatives (<F128M>a<F255D> = 0,0001) dans la quantité de rayonnement solaire participant à la photosynthèse qui atteint l'arbre. À partir d'analyses du feuillage, les auteurs ont établi que les doses d'engrais appliquées et le débroussaillement ont amélioré la quantité de nutriments assimilables par les arbres plantés sur le terrain. Grâce à des précipitations suffisantes et bien réparties, l'énergie de rétention du sol n'a jamais dépassé 0,6 bar dans tous les traitements pendant toute la saison de croissance. La température du sol a été le principal facteur influençant le taux de croissance des deux essences. L'épandage d'engrais a eu des effets bénéfiques secondaires chez le pin blanc au même titre que le débroussaillement chez l'épinette blanche. Un examen de l'évolution de l'accroissement en hauteur, de l'accroissement de la longueur des feuilles, de la surface terrière et de la masse des bourgeons apicaux révèle que les traitements de la température

du sol ont eu des effets bénéfiques pendant toute la saison de végétation, que le débroussaillement n'était important qu'à la fin de la saison, et que l'épandage d'engrais a eu des effets légèrement négatifs au début de la saison mais a donné des résultats positifs en fin de saison. Les caractères évolutifs mesurés révèlent également que les effets de la température du sol se sont traduits par une réduction de l'extension des pousses et des aiguilles des arbres, que la compétition a entraîné une diminution de la quantité disponible de lumière, de nutriments et d'humidité, et que l'épandage d'engrais a fait augmenter les teneurs en éléments nutritifs des feuilles.

34. **Brand, D.G.; Magnussen, S. 1988. Asymmetric, two-sided competition in even-aged monocultures of red pine. Can. J. For. Res. 18:901-910.**

A framework for analysis of even-aged plant monocultures was developed and used to examine hypotheses on the process of competition, using data obtained from three independently established red pine (*Pinus resinosa* Ait.) stand-density experiments. Growth rate and relative production rate (a measure of tree vigour) were computed for the individual trees in stands of differing density at points in time when these stands had the same mean stem volume. Competition is shown to be both asymmetric (small trees lose vigour more rapidly than large trees as density increases) and two-sided (not only do larger trees affect smaller trees, but to some degree small trees also cause growth reduction in larger neighbours). Increasing density results in increased size inequality as smaller trees lose vigour and become suppressed. The asymmetric, two-sided competition process in red pine stands is considered ecologically inherent for a species adapted to existence in even-aged monocultures.

Un cadre de référence pour analyser les monocultures végétales équiennes a été élaboré et utilisé dans le but de vérifier diverses hypothèses concernant les processus de compétition, à l'aide de données provenant de trois expériences tout à fait indépendantes sur la densité de peuplements de pin rouge (*Pinus resinosa* Ait.). Le taux de croissance ainsi que le taux de production relative (une mesure de la vigueur des arbres) ont été calculés pour les arbres individuels dans des peuplements dont la densité différait à des moments où ceux-ci avaient le même volume des tiges. Il est démontré que la compétition est à la fois asymétrique (les petits arbres perdent de la vigueur plus rapidement que les gros à mesure que la densité augmente) à deux pans (non seulement les gros arbres affectent-ils les plus petits, mais jusqu'à un certain point les petits arbres provoquent aussi une réduction de la croissance chez leurs voisins plus gros). Une augmentation de la densité a pour effet d'amener une inégalité accrue des dimensions des arbres à mesure que les petits arbres perdent de la vigueur et deviennent opprimés. Le processus de compétition asymétrique à deux pans dans les peuplements de pin rouge est vu comme écologiquement naturel pour une essence adaptée à vivre en monocultures équiennes.

35. **Brand, D.G.; Magnussen, S. 1990. A simulation model of the competition process in red pine plantations. Proc. Conf. Forest Stat. Pages 85-97 *in* D.R. Pelz, ed. IUFRO Section 6.02, Freiburg.**

The growth, yield, and size distribution of red pine plantations is predicted using a simulation model derived from an actual spacing trial. The model is based on adjusting the relative growth rate of individuals in a stand for the influence of competition. The competition process is described as asymmetric (changes in relative growth rate are not proportional between larger and smaller trees) and two-sided (as competition intensity increases, not only do larger trees affect their smaller neighbours, but smaller trees also affect larger neighbours). The equations used in the simulation describe these processes and as such are interpretable biologically. Parameters describing the temporal correlations of model terms were estimated by ordinary least squares techniques and employed in the simulation. Results of the simulation appear similar to other modelling approaches. Being based on process-oriented equations, however, this model is more flexible for simulating the effects of alternative management regimes where empirical data are lacking.

36. Brand, D.G.; Moore, T. 1990. Current Canadian research in forest management planning. Proc. Symp. Pages 235-241 *in* Villa, W., ed. 1990. The interlacement of enterprise management and forest management planning in forest enterprises. IUFRO WG Party S4.04-02., Dresden.

The Canadian forest is somewhat unique in that it is an extensive, publicly held resource. Most forests are harvested and managed by industrial licensees under government regulation. The primary objective of forest management in Canada is to sustain a relatively constant flow of wood products in perpetuity with limited impact on wildlife habitat, recreational opportunities, water yield, and genetic diversity. At the same time, the forest is managed extensively, meaning that forest management programs tend to flow from central decisions on how much to harvest, plant, or thin, and which stands to allocate those treatments to. Therefore, choosing the location of harvesting, protection, and silviculture activities is the primary basis of forest management planning. The actual management process, then, relies less on stand level decisions than on choosing the spatial arrangement of management activities. This form of forest management relies heavily on new technologies, including geographic information systems, decision support systems, optimization methods, and economic analysis. The field is evolving rapidly, and potential future developments are discussed.

37. Brand, D.G.; Penner, M. 1990. Interactions between vegetation competition nutrient availability, soil surface modification and the early growth of planted spruce. Pages 25-33 *in* B.D. Titus, et al., eds. The Silvics and Ecology of Boreal Spruces. 1989. IUFRO Working Party S1.05-12 Symp. Proc., Newfoundland. 12-17 Aug. 1989. For. Can. Inf. Rep. N-X-271.

Data from three experimental plantations in the boreal, sub-boreal spruce, and Great Lakes-St. Lawrence forest regions were used to quantify the effects of site modification treatments on the early growth of three species of planted spruce (*Picea glauca, Picea mariana, Picea glauca* X *engelmannii*). Soil temperature was strongly controlled by characteristics of the soil surface, and scarification increased soil temperature by 3 to 7°C on the three sites. Soil moisture availability was reduced by either uncontrolled development of competing vegetation or scarification. Nutrient availability was increased by fertilization and by brush control. These changes in environment caused changes in the ratio of foliar nonstructural carbohydrates to nitrogen. Treatments that increased carbon assimilation relative to nitrogen uptake, such as scarification, widened this ratio, while treatments that increased nitrogen availability more than carbon, such as fertilization, reduced this ratio. Changes in the availability of one environmental factor, such as light, affected the efficiency of use of other factors such as nitrogen. Growth responded most to the control of competing vegetation on all three study sites. Use of scarification before planting also reduced the rate of development of competing vegetation and, through improvements in soil temperature, increased growth beyond the response expected from differences in non-crop competition alone. Fertilization was most effective at increasing tree growth when vegetation was controlled or the soil surface scarified. The spruce species studied showed 300% to 1500% increas in biomass across the range of treatments tested, indicating the opportunity for improvements in the success rate of spruce reforestation programs.

38. Burgess, D. 1990. White and black spruce seedling development using the concept of relative addition rate. Scand. J. For. Res. 5:471-480.

Ingestad's concept of relative addition rate was used to grow a range of seedling types, of both black [*Picea mariana* (Mill.) B.S.P.], and white spruce [*Picea glauca* (Moench) Voss]. Seedlings were grown for about 18 weeks in styrofoam containers under greenhouse conditions and fertilized at exponentially increasing rates of either one, two, four or six per cent per day, following a one month pretreatment period. Pretreatment consisted of applying a nutrient solution proportionally low in nitrogen, but that had a relatively high conductivity compared to the initial solutions used in the exponentially increasing fertilizer treatments. Black spruce seedlings grew fastest, had significantly more root development or had a higher efficiency of nitrogen uptake when nutrients were applied at

exponentially increasing amounts. In contrast, white spruce grew more rapidly when fertilized with a constant level of fertilizer (control treatment). Biomass allocation and nitrogen concentrations in seedlings of both species varied significantly with treatment, indicating that various levels of nitrogen stress had been achieved. It is suggested that different seedling stock types, which are acclimated to various levels of nutrient stress, can be produced by controlling the rate of nutrient addition.

39. **Burgess, D.; Hendrickson, O. 1989. Early development of poplar and willow clones interplanted with alder. Pages 212-219 *in* Worrall, J. et al., eds. Proc. Tenth N. Amer.Forest Biol. Workshop, Vancouver, B.C., Univ. B.C., Vancouver.**

Interplanting with nitrogen-fixing alders had a slight positive effect on growth of hybrid poplar clones within the first six years after outplanting. The two exotic tree-alder species tested evertopped the willow clones, and *Alnus incana* ssp. *incana* (L.) Moench outgrew a more commonly planted species, *A. glutinosa* (L.) Gaertn. Foliar or total soil N levels were not affected significantly by treatment, but there was evidence of higher nitrate levels and nitrification activity, and lower pH, in the interplanted plots.

40. **Burgess, D.; Hendrickson, O.Q.; Roy, L. 1990. The importance of initial cutting size for improving the growth performance of *Salix alba* L. Scand. J. For. Res. 5:215-224.**

Survival and early growth and yield of *Salix alba* L. over two successive 2-year rotations were evaluated under nursery conditions that included irrigation during the first growing season. A six-year-old coppice of *Salix alba* was used as a source of cuttings. Cuttings were planted in single row plots at a 30 cm spacing within rows and 100 cm between rows. Cuttings ranged in size from <0.6 to 3.2 cm in diameter and 7.6 to 45.7 cm in length. Use of small cuttings resulted in lower survival with survival rates ranging from 13.3 to 100%. Cutting length and diameter were both significant factors, but cutting length was the most critical. The smallest cuttings that resulted in 100% survival after two rotations were 0.6 to 1.3 cm in diameter and 30.0 cm in length. Stem number, cumulative height, and biomass all increased markedly with use of larger cuttings up to a certain size and ranged on a per stool basis from 17.3 to 23.4, 14.3 to 20.2 m, and 194 to 300 g, respectively, at the end of the second rotation. Use of cuttings larger than 1.3 to 1.9 cm in diameter and 22.9 cm in length did not result in any significant improvement in growth. The conclusions are that cutting size can be an important factor influencing early plantation performance and use of mini-cuttings to establish fast-growing plantations is not recommended.

41. **Caron, G.E.; Wang, B.S.P.; Schooley, H.O. 1989. Germination of apparently mature white spruce seeds following cone storage and prechilling. Pages 342-347 *in* Worall, J. et al., eds. Proc. Tenth N. Amer. Forest Biol. Workshop, Vancouver, B.C., Univ. B.C., Vancouver.**

Cones collected from 18 open-pollinated, 30-year-old white spruce (*Picea glauca* (Moench) Voss) at the time of natural seed dissemination were stored in a well-ventilated building for 2 to 6 weeks before seed extraction. When cones were stored for 2 weeks, non-prechilled and prechilled seeds averaged 32.0 ± 18.9% (X ± s.e.) and 62.3 ± 20% germination, respectively. When cones were stored for 6 weeks, non-prechilled and prechilled seeds averaged 61.3 ± 24.4% and 94.7 ± 4.0% germination, respectively. The significantly higher germination percentage, germination rate, and lower tree to tree variation for prechilled seeds from cones stored for 6 weeks indicate that seed maturation was promoted by post-harvest cone storage prior to seed extraction. Average seed dormancy remained about the same from 2 to 6 weeks of storage; however, seeds from some trees became more dormant with the storage period whereas those from other trees became less dormant.

42. Caron, G.E.; Wang, B.S.P.; Schooley, H.O. 1990. Effect of tree spacing, cone storage, and prechilling on germination of *Picea glauca* seed. For. Chron. 66:388-392.

Cones were collected in 1984 at the time of natural seed dissemination from 18 open-pollinated, 30-year-old white spruce (*Picea glauca* (Moench) Voss) trees at 1.2, 2.4, and 4.9 m spacings in a demonstration seed production area at Petawawa National Forestry Institute. Cones were stored in a well-ventilated building for 2 to 6 weeks before seed extraction.

Cones length, full-seed-yield per cone, and full-seed weight were greatest for cones collected from trees at the 1.2 m spacing. When cones were stored for 2 weeks, non-prechilled and prechilled seeds averaged 32.0 ± 1.0% (x ± s.e.) and 62.3 ± 1.0% germination, respectively. When cones were stored for 6 weeks, non-prechilled and prechilled seeds averaged 61.3 ± 1.2% and 94.7 ± 0.5% germination, respectively. The higher germination percentage, germination rate, and lower tree to tree variation for prechilled seeds from cones stored for 6 weeks indicate that seed maturation was promoted by post-harvest cone storage prior to seed extraction. Average seed dormancy remained about the same from 2 to 6 weeks of storage; however, seeds from some trees became more dormant with the storage whereas those from others became less dormant. Relationship between seed weight and germination was weak.

Une collecte de cônes a été entreprise en 1984, durant la période de dissémination naturelle des semences, à partir de 18 épinettes blanches (*Picea glauca* (Moench) Voss) âgées de 30 ans. Ces arbres faisaient partie d'une plantation établie pour la production semencière à l'Institut national forestier de Petawawa où l'espacement était soit de 1,2; 2,4 ou 4,9 m. Les cônes récoltés ont été entreposés pendant 2 à 6 semaines jusqu'au moment de l'extraction.

La longueur des cônes, la quantité de semences pleines, et le poids des semences ont été supérieurs pour les cônes provenant du plus petit espacement. Les cônes entreposés pendant 2 semaines eurent une germination moyenne respective de 32,0 ± 1.0% et 62,3 ± 1.0% pour les semences non-refroidies et refroidies. Ceux entreposés pendant 6 semaines eurent une germination moyenne respective de 61,3 ± 1,2% et 94,7 ± 0,5% pour les semences non-refroidies et refroidies. Le pourcentage et le taux élevés de germination, et leur faible variation entre les arbres suite au refroidissement des semences et à l'entreposage des cônes pendant 6 semaines indiquent la promotion de la maturation chez les semences entreposées. La dormance moyenne des semences changea peu entre 2 et 6 semaines d'entreposage; les semences de certains arbres devinrent plus dormantes tandis que celles d'autres devinrent moins dormantes. Une relation faible a été décelée entre la pesanteur des semences et le pourcentage de germination.

43. Case, A.B.; Wang, B.S.P. 1990. Helping reforestation in Southeast Asia - the ASEAN-Canada Forest Tree Seed Centre Project. For. Chron. 66:246-249.

The ASEAN-Canada Forest Tree Seed Centre Project is a key development initiative by Canada in addressing the growing deforestation problems in tropical regions. The Centre was established in 1981 as a cooperative venture between Canada and the Association of Southeast Asian Nations to help overcome difficulties in acquiring and producing operational quantities of high quality seed and planting material from regional reforestation programs. The Project entered its second phase in 1989 under the direction of Forestry Canada, Petawawa National Forestry Institute. Phase II of the Project is described in terms of Canada's inputs and the anticipated outputs over the 6-year period, 1989-1995.

Initié par le Canada, le développement du Centre de semences forestières Canada-ASEAN est un programme-clé qui vise les solutions aux problèmes plus en plus graves du déboisement. Le Centre a été fondé en 1981, grâce à la coopération entre le Canada et l'Association des Nations de l'Asie du Sud-Est. Le but est de promouvoir la production et la collecte de semences forestières de grande qualité et en

quantité suffisante pour les programmes régionaux de reboisement. Ce programme, dont la deuxième phase a commencé en 1989, est dirigé par l'Institut forestier national de Petawawa qui relève de Forêts Canada. Dans le présent document sont décrits les efforts déployés par le Canada de même que les résultats prévus au cours de la période de 1989-1995.

44. Chaichanasuwat, O.; Wang, B.S.P.; Wasuwanich, P. 1990. Evaluating seed quality of *Peltophorum pterocarpum* by x-radiography and germination. Pages 68-71 *in* Turnbull, J.W., ed. 1990. Tropical tree seed research. Aust. Centre Intl. Agr. Res., Canberra, ACT, Proc. No. 28.

Based on x-radiographic images of seed development and the degree of decay, four anatomical classes can be recognized and reliably used for estimating the germination potential of *Peltophorum pterocarpum* Back. ex Heyne seeds. Germinability estimated by x-radiography compared equally well with the germination test results. Among all the seed pretreatments applied, the most effective and practical was soaking seeds in concentrated H_2SO_4 for 45 minutes.

45. Chakravarty, P.; Chatarpaul, L. 1988. The effects of Velpar L (hexazinone) on seedling growth and ectomycorrhizal symbiosis of *Pinus resinosa*. Can. J. For. Res. 18:917-921.

The authors investigated the effects of Velpar L (hexazinone) on ectomycorrhizal (*Laccaria laccata*) and nonmycorrhizal *Pinus resinosa* seedlings in the greenhouse and in the field. In both greenhouse and field studies, seedling growth was reduced by Velpar L at 1, 2, and 4 kg/ha application rates in the short term (2 months' exposure) with significant recovery occurring afterwards. Seedling mortality occurred only with herbicide treatments and was higher in the greenhouse than in the field. The 4 kg/ha Velpar L treatment caused the highest mortality and toxicity was most pronounced in the mycorrhizal (*Laccaria laccata* inoculated) seedlings. In both experiments mycorrhizal infection was significantly reduced by 2 and 4 kg/ha Velpar L treatments during the 0- to 2-month and 2- to 6-month exposure periods, with significant recovery occurring in the latter. Although seedlings not infected with *Laccaria laccata* became mycorrhizal through unidentified indigenous species, their infection rates were also affected by Velpar L at all levels during the 0- to 2-month period and at the 2 and 4 kg/ha levels after 2-6 months of exposure to the herbicide.

Les auteurs ont étudié les effets du Velpar L (hexazinone) sur des semis de *Pinus resinosa* ectomycorhizés (*Laccaria laccata*) et non mycorhizés traités en serre et au champ. Des applications de Velpar L de l'ordre de 1, 2 et 4 kg/ha ont eu pour effet immédiat (exposition de 2 mois) de réduire la croissance des semis qui ont, par la suite, énormément récupéré, tant en serre qu'au champ. Seuls les traitements herbicides ont entraîné la mortalité de semis, le taux de mortalité étant plus élevé en serre qu'au champ. L'application d'une dose de 4 kg/ha de Velpar L a provoqué le taux de mortalité le plus élevé, et la toxicité était plus marquée chez les semis mycorhizés (inoculés de *L. laccata*). Lors des deux expériences, les doses de 2 et de 4 kg/ha réduisaient énormément l'infection mycorhizienne de 0 à 2 mois et de 2 à 6 mois après l'exposition, une récupération significative se produisant pendant cette dernière période. Bien que des semis non inoculés de *L. laccata* aient été mycorhizés par des espèces indigènes non identifiées, les trois doses de Velpar L de 0 à 2 mois après l'exposition et les doses de 2 et de 4 kg/ha de 2 à 6 mois après l'exposition à l'herbicide ont également affecté leur degré d'infection.

46. Chakravarty, P.; Chatarpaul, L. 1990. Effect of fertilization on seedling growth, ectomycorrhizal symbiosis, and nutrient uptake in *Larix laricina*. Can. J. For. Res. 20: 245-248.

Container-grown *Larix laricina* (Du Roi) K. Koch seedlings were inoculated with the ectomycorrhizal fungus *Laccaria laccata* (Scop. ex Fr.) Berk and Br. and grown under two levels of slow-release fertilizer (Osmocote) or two levels of soluble fertilizer (N-P-K). Nonmycorrhizal seedlings grew better under high fertility regimes, whereas no significant differences were observed between low and high fertility levels for the mycorrhizal seedlings. Mycorrhizal seedlings had significantly greater root

length, total biomass, and a lower shoot:root ratio under all fertility treatments. Ectomycorrhizal development was excellent regardless of fertilizer treatment. Nitrogen, P, K, Ca, and Mg concentrations were significantly higher in the mycorrhizal seedlings than in the nonmycorrhizal seedlings under all fertility regimes.

Des semis de *Larix laricina* (Du Roi) K. Koch produits en contenants sont inoculés avec le champignon ectomycorhizien *Laccaria laccata* (Scop. ex Fr.) Berk and Br. et soumis à différents régimes de fertilisation. les plants sont fertilisés soit avec de l'engrais à effet prolongé (Osmocote) soit avec de l'engrais soluble (N-P-K), appliqué à deux niveaux chacun. Les semis non mycorhizés se développent mieux aux niveaux supérieurs de fertilisants, alors que l'on observe aucune différence significative entre les niveaux inférieur et supérieur de fertilisants pour les plants mycorhizés. Les semis mycorhizés ont, de façon significative, des racines plus longues, une biomasse totale plus élévée et un rapport tige/racine plus petit comparé aux semis non mycorhizés, indépendamment des niveaux de fertilisation. Le développement ectomycorhizien est excellent, indifféremment du traitement de fertilisation. Les semis mycorhizés contiennent des quantités significativement plus élévées de N, P, K, Ca et Mg que les non-mycorhizés, à tous les niveaux de fertilisation utilisés.

47. **Chakravarty, P.; Chatarpaul, L. 1990. Non-target effect of herbicides: I. Effect of glyphosate and hexazinone on soil microbial activity. Microbial population, and *in-vitro* growth of ectomycorrhizal fungi. Pestic. Sci. 28:233-241.**

The effects of two herbicides, glyphosate (as a 359 g litre^{-1} SL) and hexazinone (as a 50 g kg^{-1} granule) on soil microbial population, carbon dioxide evolution, and *in-vitro* growth of five species of ectomycorrhizal fungi were investigated. Glyphosate at 0.54 and 3.23 kg a.i. ha^{-1} and hexazinone at 1, 2 and 8 kg a.i. ha^{-1} did not reduce soil microbial population or carbon dioxide evolution in the long term (6 months). However, there was a significant short-term (2 months) effect of glyphosate on both fungal and bacterial counts at the 0.54 kg ha^{-1} treatment. In *in-vitro* tests, *Cenococcum graniforme*, *Hebeloma crustuliniforme* and *Laccaria laccata* were more suscepitble to both herbicides than was *Suillus tomentosus*, which was, in turn, more susceptible than *Paxillus involutus*. The growth of all five ectomycorrhizal fungi was significantly reduced when subjected to concentrations above 50 µl formulation litre^{-1} (glyphosate) or 50 µg formulation litre^{-1} (hexazinone).

48. **Chakravarty, P.; Chatarpaul, L. 1990. Non-target effect of herbicides: II. The influence of glyphosate on ectomycorrhizal symbiosis of red pine (*Pinus resinosa*) under greenhouse and field conditions. Pestic. Sci. 28:243-247.**

The effects of the herbicide glyphosate [N-(phosphonomethyl) glycine] on seedling growth of *Pinus resinosa* and on the ectomycorrhizal development of the symbiotic fungus *Paxillus involutus* were investigated under greenhouse and field conditions. Glyphosate at 0.54 and 3.23 kg ha^{-1} did not reduce seedling growth or ectomycorrhizal development under greenhouse conditions. There was no seedling mortality due to glyphosate treatment of either rate. Under field conditions, seedling growth of *P. resinosa* and ectomycorrhizal development of *P. involutus* were not affected by the above rates. Seedlings (46-48%) failed to survive in non-glyphosate-treated plots, presumably because of weed competition, whereas all survived in glyphosate-treated plots. All the non-mycorrhizal seedlings were colonized by indigenous mycorrhizal fungi within 2 months after planting in both control and glyphosate-treated plots. The infection rates varied from 74-86%.

49. **Chakravarty, P.; Chatarpaul, L.; Subramaniam, P. 1990. The effects of glyphosate [N-(phosphonomethyl) glycine] on soil microbial activity and mycorrhizal development of *Pinus resinosa* seedlings. Pages 103-108 *in* Lalonde, M., Piché, Y., eds. Can. Wkshp. Mycorrhizae in Forestry. C.R.B.F., Faculté de Foresterie et de Géodésie, Université Laval, Ste-Foy, Qc.**

The effect of glyphosate [N-(phosphonomethyl) glycine] on soil microbial activity, *in vitro* growth of four species of ectomycorrhizal fungi, seedling growth and mycorrhizal (*Paxillus involutus*) incidence of *Pinus resinosa* were investigated. Under field conditions, glyphosate at two levels of application (1.5 and 9 $L.ha^{-1}$) did not reduce soil fungal and bacterial population and CO_2 evolution. *In vitro* growth of four species of ectomycorrhizal fungi was not affected by glyphosate up to 10 $\mu L.L^{-1}$, however, significant reduction in growth of all the species occurred at 50-1000 $\mu L.L^{-1}$. Seedling growth and mycorrhizal (*Paxillus involutus*) development of *P. resinosa* were not affected by glyphosate at both 1.5 and 9 $L.ha^{-1}$ rates under greenhouse and field conditions. In the field, non-mycorrhizal seedlings were colonized by unidentified indigenous mycorrhizal fungi and their infection was unaffected by glyphosate at both rates, 2 months after planting.

50. **Charest, P.J.; Hattori, J.; DeMoor, J.; Iyer, V.N.; Miki, B.L. 1990. In vitro study of transgenic tobacco expressing *Arabidopsis* wild type and mutant acetohydroxyacid synthase genes. Plant Cell Rep. 8:643-646.**

Genes coding for the enzyme acetohydroxyacid synthase, often referred to as acetolactate synthase (AHAS, ALS; EC 4.1.3.18), from wild type *Arabidopsis thaliana* and a sulfonylurea-resistant mutant line GH50 (*csr*1-1; Haughn et al. 1988) were introduced in *Nicotiana tabacum*. Both genes were expressed at high levels with the 35S promoter. The *csr*1-1 gene conferred high levels of resistance to chlorsulfuron whereas the wild type gene did not. As selectable markers, chimaeric AHAS genes yielded transgenic plants on chlorsulfuron but at much lower efficiencies than with a chimaeric neomycin phosphotransferase gene on kanamycin (Sanders et al. 1987). Shoot differentiation from leaf discs was delayed on chlorsulfuron by 4-6 weeks. This study indicated a role for mutant AHAS genes in the genetic manipulation of herbicide resistance in transgenic plants but as selectable markers for plant cells undergoing differentiation no advantage over other genes was perceived.

51. **Charest, P.J.; Pitel, J.; Cheliak, W.M.; DeVerno, L.; Tremblay F.M.; Klimaszewska, K.K. 1989. Molecular genetics and tissue culture of forest tree species at the Petawawa National Forestry Institute (1988-1989). Pages 91-94 *in* Magnussen, S.; Boyle, T.J.B., eds. Proc. 22nd Meeting CTIA Part I, Edmonton, Alta.**

Research at the Institute on somatic embryogenesis in conifers has progressed well. Routine protocols have been established for initiation of embryogenic callus from immature seeds of two *Larix* species and their reciprocal hybrids, and from mature seeds of black, white, and red spruce. As well, the genotype effect on initiation frequency of embryogenic callus has been studied in 20 families of black spruce. A high frequency of maturation and germination of somatic embryos has been achieved in hybrid larch and black spruce, and somatic embryo-derived plants of these species have been established in soil and transferred to the nursery. Protoplast systems leading to the regeneration of plants have been developed for hybrid larch and are being used for genetic transformation experiments. Cryopreservation procedures for long-term storage of embryogenic calli and cell suspensions of hybrid larch and black spruce have been developed. Plants have been regenerated from thawed tissues and are now in a nursery. Somatic embryogenesis is the first step to applications in molecular genetics studies and toward the development of artificial seeds.

52. Chatarpaul, L.; Chakravarty, P.; Subramaniam, P. 1990. Ectomycorrhizal effects on nodulation, nitrogen fixation, and growth of *Alnus glutinosa* as affected by glyphosate. Pages 309-320 *in* Dhawan, V., ed. 1989. Applications of biotechnology in forestry and horticulture. Plenum Press, New York.

Actinorhizal plants such as *Alnus* and *Casuarina* offer good potential for increasing the productivity of impoverished soils because of their ability to fix atmospheric nitrogen in a symbiotic relationship with the actinomycete, *Frankia*. The occurrence of mycorrhizae on actinorhizal plants is seen as a hypersymbiosis which could be of added nutritional significance. To test this hypothesis, the effects of an ectomycorrhizal fungus, *Paxillus involutus*, on *Alnus glutinosa* seedlings nodulated with *Frankia* were investigated in the greenhouse and in the field both in the absence and presence of the herbicide, glyphosate. Under greenhouse conditions, simultaneous inoculation with *Frankia* and *Paxillus involutus* stimulated biomass production, nodulation and acetylene reduction in the absence of glyphosate. Glyphosate at 1.5 l ha^{-1} stimulated biomass production and acetylene reduction, but tempered the influence of the tripartite association. The 9.1 ha^{-1} glyphosate treatment reduced shoot growth, stimulated root growth, and further reduced the impact of the tripartite association. In the field, at the end of one season, about 45 percent of the seedlings failed to survive in the non-herbicide treated plots, whereas all survived the 1.5 l ha^{-1} and 9.1 ha^{-1} treatments. Trends were similar to those observed in the greenhouse. In *in vitro* studies, pure cultures of *Frankia* and *Paxillus involutus* were treated with different concentrations of glyphosate. At concentrations of up to 10 ppm, neither of the two organisms were affected by glyphosate but their growth was significantly reduced by the 50-1000 ppm treatments. The authors' results indicate significant enhancement in the performance of *Alnus glutinosa* seedlings when inoculated with both *Frankia* and *Paxillus involutus*. Recommended application rates of glyphosate may not have any negative effects on growth.

53. Chatarpaul, L.; Chakravarty, P.; Subramaniam, P. 1990. Studies in tetrapartite symbioses. Plant Soil 118:145-150.

Alnus incana seedlings were successfully inoculated with an endomycorrhizal fungus (*Glomus fasciculatus*), an ectomycorrhizal fungus (*Paxillus involutus*) and an isolate of *Frankia* (ACN1) simultaneously. The effects of the inoculation treatments on the growth performance of the seedlings were evaluated under controlled conditions.

The overall growth performance of the seedlings inoculated with the three organisms was better than those inoculated with *Frankia*, *G. fasciculatus*, and *P. involutus* indivudally or with *Frankia* + *G. fasciculatus* and *Frankia* + *P. involutus* combinations. The highest growth performance and mycorrhizal infection occurred when the seedlings were inoculated simultaneously with *Frankia* + *G. fasciculatus* + *P. involutus*.

54. Chatarpaul, L.; Lachance, D. 1990. Is birch a suitable reference in estimating dinitrogen fixation in alders by isotope dilution? Plant Soil 118:43-50.

Seedlings of *Alnus incana* (nodulated and non-nodulated) and *Betula papyrifera* were fertilized with varying amounts (0, 10, 25, 50, 100, 250, and 500 µg Ng^{-1} soil) of labelled ammonium-N or nitrate -N (~5.2 A% excess ^{15}N as ammonium sulphate or potassium nitrate). After 4 months in the greenhouse, ^{15}N excess in the plants were determined and an isotope dilution equation was applied to determine the percent of biomass N fixed by the *A. incana*/*Frankia* system. When ammonium was used as the sole N source and birch as the non-fixing reference, N-fixation accounted for 95%, 87% and 60% of the plant nitrogen yields with 10, 25, and 50 µg Ng^{-1} rates, additions respectively. At the 100 µg Ng^{-1} fertilization and above N-fixation accounted for less than 10% of the N yield. Similar results were obtained when non-nodulated *A. incana* was used as non-fixing reference. With nitrate as the sole N source, N-fixation accounted for 98%, 97%, 97%, 86%, 56%, and 12% of N yield with 10, 25, 50, 100, 250,

and 500 μg Ng^{-1} additions, respectively. These values were similar for both types of reference plants. The direct isotope dilution method was compared to that of the total nitrogen difference method. There was good agreement between the two methods up to 50 μg Ng^{-1} for ammonium and up to 100 μg Ng^{-1} for nitrate. The difference method produced negative values at high concentrations of nitrogen fertilization. Again, similar results were obtained by the two reference plants. The results indicate that birch can be used as a non-fixing control in isotope dilution studies but care must be exercised in selecting the type and quantity of labelled nitrogen fertilizer.

55. Cheliak, W.M.; Klimaszewska, K. 1990. Cell, protoplast, and tissue culture of short-rotation species. Biomass 22:63-73.

Gamma-irradiated and non-irradiated cell suspensions of hybrid poplar NM1 (*Populus nigra* x *P. maximowiczii*) were used to select cells that had a higher tolerance to the active ingredient in the herbicide Roundup. Numerous cell lines were recovered that were able to grow, at about 60% of the control lines, in 10 mM glyphosate. These cells were transferred to an embedded single-cell regeneration system which was used to recover calli regenerated in the presence of 10 mM glyphosate. The calli were transferred to glyphosate-free medium for shoot elongation.

56. Cheliak, W.M.; Murray, G.; Pitel, J.A. 1988. Genetic effects of phenotypic selection in white spruce. For. Ecol. Manage. 24:139-149.

Phenotypically selected individuals, to be used in a breeding program, and randomly selected individuals of white spruce (*Picea glauca* Moench Voss) were sampled from nine stands within a breeding region to document impacts of early domestication in a wild species. Needles from both selected and random samples were surveyed for electrophoretically detectable genic variation at 12 different enzyme systems. Average heterozygosity (0.172) was comparable to geographically broader surveys of this species. Although a large number of unique and rare alleles were observed, only 0.7% of the variation was attributable to the among-stand component. No changes in genotypic structure were associated with phenotypic selection using this set of molecular markers. Because of this lack of association, the isozymes could serve as an independent set of neutral variables to monitor variation. Allele frequency and heterozygosity were not significantly different in the selected versus random populations. There were, however, differences between the two population samples when measures of allelic richness were contrasted. Only 75% of the alleles were represented in the selected population. Implications of these changes on the utility of phenotypically selected populations as gene conservation samples, and their representativeness as breeding populations, are discussed.

57. Cheliak, W.M.; Rogers, D.L. 1990. Integrating biotechnology into tree improvement programs. Can. J. For. Res. 20:452-463.

Time is a major constraint in the progress of tree improvement programs. Four ways in which time influences the tree improvement process are (i) evolutionary time, (ii) time to harvest, (iii) time to achieve phenotypic stability, and (iv) time to reach reproductive maturity. The ways in which each of these affects the three phases of a tree improvement program (conservation, selection and breeding, and propagation) are identified and discussed. How biotechnological techniques, as well as other enabling technologies, address the time constraint problem is also discussed. The biotechnological approaches include tissue culture, molecular genetics, and genetic engineering; the enabling technologies include early testing and flower induction. Through tissue culture it is possible to increase genetic gain per unit time and increase total genetic gain by using more of the total genetic variation. Development of high-resolution linkage maps, through application of molecular genetics technology, will provide new approaches to early screening, testing, and selection. Additionally, molecular probes will be useful in improving methods that genetically fingerprint germplasm. Genetic engineering has considerable potential to reduce time constraints. However, because of the diverse breeding and production populations typically employed, much basic work needs to be done to integrate genetically engineered

materials into tree improvement programs. Early selection and flower induction address the time constraints imposed by age-stable performance and reproductive maturity. When used in combination with the previously described biotechnologies, a powerful system is created that can dramatically reduce the time required to integrate genetically improved material into forest regeneration programs. An example of integrating tree improvement, clonal forestry, and biotechnology is described for an existing black spruce regeneration program.

Le temps constitue une entrave importante au progrès de tout programme d'amélioration des arbres. Voici quatre façons dont le temps influence l'amélioration des arbres : (i) le temps nécessaire à l'évolution, (ii) le temps nécessaire à la récolte, (iii) le temps nécessaire pour atteindre la stabilité phénotypique et (iv) le temps nécessaire pour atteindre la maturité reproductive. La façon dont chacun affecte les trois phases d'un programme d'amélioration des arbres (la conservation, la sélection et l'hybridation, et la propagation) est identifiée et discutée. Il est aussi question de la façon dont les techniques biotechnologiques et les autres techniques de support abordent le problème lié aux contraintes de temps. Les approches biotechnologiques incluent la culture de tissus, la génétique moléculaire et le génie génétique; les techniques de support incluent les tests précoces et l'induction de la floraison. La culture de tissus permet d'augmenter le gain génétique par unité de temps, aussi bien que le gain génétique total en utilisant une plus grande partie de la variabilité génétique totale. Le développement de chartes de liens génétiques de haute précision fournira de nouvelles approches pour la détection précoce, les essais et la sélection. De plus, les sondes moléculaires serviront à améliorer les méthodes d'identification du patrimoine héréditaire. Les manipulations génétiques ont un potentiel considérable pour réduire les contraintes de temps. Cependant, à cause de la diversité des populations généralement utilisées pour l'hybridation et la production, beaucoup de recherche fondamentale reste à faire pour intégrer le matériel génétiquement transformé dans les programmes d'amélioration des arbres. La sélection précoce et l'induction florale réduisent les contraintes de temps reliées à l'âge nécessaire pour obtenir une performance stable et à la maturité requise pour la reproduction. En utilisant ces techniques conjointement avec les techniques biotechnologiques mentionnées précédemment, on obtient un système puissant capable de réduire de façon dramatique le temps nécessaire à l'intégration du matériel génétiquement amélioré dans les programmes de régénération forestière. On donne un exemple qui intègre l'amélioration des arbres, la foresterie clonale et la biotechnologie pour un programme existant de régénération de l'épinette noire.

58. **Cheliak, W.M.; Wang, J.; Pitel, J.A. 1988. Population structure and genic diversity in tamarack, *Larix laricina* (Du Roi) K. Koch. Can. J. For. Res. 18:1318-1324.**

Levels of electrophoretically detectable variation at 19 loci were estimated in 36 populations representing the natural range of *Larix laricina* (Du Roi) K. Koch. Results of this survey indicated that the species has levels of genic variation comparable with those of other species of woody perennials with extensive transcontinental ranges. There was no evidence of significant departures from Hardy-Weinberg expectation. However, on average, populations of this species were more differentiated and more genetically divergent from one another compared with many randomly mating tree species. A discriminant analysis of the genotypic structure of the populations analyzed indicated a general east versus west pattern, with populations in the Great Lakes basin being further differentiated. Present-day population distribution, population density, and reinvasion routes after the last glaciation could account for the observed patterns of genic variation.

Les degrés de variation détectables par électrophorèse ont été estimés dans 19 loci chez 36 populations issues de l'aire d'extension naturelle de *Larix laricina* (Du Roi) K. Koch. Les résultats de cette étude révèlent que le degré de variation génique de cette essence est comparable à celui des autres espèces ligneuses pérennes dont l'aire naturelle d'extension est transcontinentale. Rien ne prouve l'existence d'une déviation importante par rapport à la loi de Hardy-Weinberg. Cependant, en moyenne, les populations étaient plus différenciées et génétiquement divergentes les unes des autres en comparaison de nombreuses essences forestières se reproduisant librement. Une analyse discriminante de la structure

génotypique des populations examinées a révélé l'existence d'un profil général à l'est (contrairement à l'ouest), les populations du bassin des Grands Lacs étant les plus différenciées. La répartition actuelle des populations, leur densité et les voies de pénétration empruntées après la dernière glaciation pourraient expliquer les profils de variation génique observés.

59. **Cheliak, W.M.; Yapa, A.C. eds. 1988. Biotechnology in Energy Forestry: IEA symposium abstracts. PI-X-84.**

Seven short summaries of papers given at a symposium held at PNFI.

60. **Cheliak, W.M.; Yapa, A.C., eds. 1988. Molecular genetics of forest trees. PI-X-80.**

This is a series of thirteen papers presented by participants at the Second Workshop of the IUFRO Working Party on Molecular Genetics, convened at the Petawawa National Forestry Institute.

61. **Cheliak, W.M.; Yapa, A.C., édit. 1989. Biotechnologie et sylviculture énergétique : Résumés du symposium de l'AEI. PI-X-84F.**

Sept résumés courts d'après les exposés présentés à un symposium à l'IFNP.

62. **Clark, W.R. 1989. Canada, forestry, and the FAO. PI-X-90.**

The Food and Agriculture Organization (FAO) of the United Nations held its founding conference in Canada in 1945 and, as of June 1988, had 158 member nations. FAO is the international organization most active in the forestry sector, currently spending a total of over US$ 55 million per year in this area (9.5% of the FAO total): $46 million on its 214 forestry field projects around the developing world, and $9 million on its Department of Forestry at FAO headquarters in Rome, Italy. Presently, seven of the 61 professional and higher staff in the department are Canadians, and Canada indirectly contributes nearly US$ 0.5 million annually to FAO's various forestry programs. This report details the purpose, organization, resources, and activites of FAO and its many forestry-related subsidiary bodies, highlighting Canadian participation.

63. **Clark, W.R. 1990. Le Canada, la foresterie et la FAO. PI-X-90F.**

Issue d'une conférence tenue au Canada en 1945, l'Organisation des Nations Unies pour l'alimentation et l'agriculture (O.A.A./FAO) comptait 158 pays membres en juin 1988. La FAO est le principal organisme international œuvrant dans le secteur forestier y consacrant annuellement 9,5 % de son budget total, soit plus de 55 millions de dollars américains : 46 millions sont affectés à 214 programmes sur le terrain dans les pays en voie de développement et 9 millions sont alloués au Département des forêts de l'administration centrale de la FAO à Rome. Sept Canadiens figurent parmi les 61 experts et cadres supérieurs du département. Le Canada verse indirectement quelque 500 000 dollars américains à la FAO pour ses divers programmes forestiers. Ce rapport décrit en détail le but, l'organisation, les ressources et les activités de la FAO et de ses nombreux organismes subsidiaires œuvrant dans le domaine de la foresterie, tout en mettant l'accent sur la participation canadienne.

64. **Copis, P.L. 1990. Pollination techniques. I. Pollen collection. PNFI Technical Reports, No. 4.**

65. **Copis, P.L. 1990. Pollination techniques. II. Pollen extraction and storage. PNFI Technical Reports, No. 5.**

66. **Copis, P.L. 1990. Pollination techniques. III. Flower development rating and pollen application. PNFI Technical Reports, No. 7.**

67. D'Eon, S.P.; Power, J.M. 1989. The Acid Rain National Early Warning System (ARNEWS) plot network. PI-X-91. 119 p.

Forestry Canada has established a network of forest plots across Canada for the Acid Rain National Early Warning System. These plots are remeasured on a regular basis to enable detection and monitoring of changes in forest health. The report describes the tree and stand characteristics of each of the 103 plots at the time of plot establishment.

Forêts Canada a établi un réseau de parcelles forestières expérimentales à travers le Canada pour le Dispositif nationale de l'alerte rapide des pluies acides. Ces parcelles ont été remesurées de façon régulière pour surveiller et déceler les changements dans l'état de santé des forêts. Ce rapport traite les caractéristiques des arbres et celles des parcelles au moment de l'installation.

68. DeVerno, L.L.; Byrne, J.R.; Pitel, J.A.; Cheliak, W.M. 1989. Constructing conifer genomic libraries: a basic guide. PI-X-88.

Procedures are given for constructing genomic DNA bacteriophage libraries from conifer tissue. Although black spruce *Picea mariana* (Mill.) B.S.P. tissue was used, the protocols can be applied to any plant species. Included are techniques for high molecular weight genomic DNA isolation from mature needles, seedlings, and cell suspension cultures. In addition, purification of size-fractionated genomic DNA fragments, vector DNA isolation, and preparation of vector arms are outlined. Details are provided for production of recombinant clones, *in vitro* packaging, amplification, and evaluation of library quality. Appendices contain methods for purification of sized fragments, media and buffer formulas, and the number of recombinants required to represent genomes of various species.

69. DeVerno, L.L.; Byrne, J.R.; Pitel, J.A.; Cheliak, W.M. 1990. Création d'une banque génomique pour les conifères : un guide de base. PI-X-88F.

Ce rapport décrit la manière de créer une banque de bactériophages à ADN génomique à partir de tissus de conifères, en l'occurrence des épinettes noires (*Picea mariana* [Mill.] B.S.P.). La méthode peut être appliquée à toutes les espèces végétales. On présente notamment des techniques pour isoler des fragments d'ADN génomique à poids moléculaire élevé à partir d'aiguilles mûres, de semis et de cultures contenant des cellules en suspension. Les auteurs décrivent également la purification de fragments d'ADN génomique fractionnés en fonction de la taille, l'isolation de l'ADN vecteur et la préparation des bras de vecteur. Y sont également détaillés la production de clones recombinants, l'emballage *in vitro*, l'amplification et l'évaluation de la qualité de la banque. Les annexes contiennent des méthodes de purification des fragments, des milieux et des préparations de tampons. Elles font aussi état du nombre de recombinants nécessaires pour représenter les génomes de diverses espèces.

70. Duchesne, L.C.; Jeng, R.S.; Hubbes, M.; Sticklen, M.B. 1990. Accumulation of mansonones E and F in seedlings of *Ulmus americana* in response to inoculation with *Ophiostoma ulmi*. Trees 4:187-190.

The accumulation of mansonones E and F was investigated in *Ulmus americana* L. seedlings 5 weeks after inoculation with three aggressive and three non-aggressive isolates of *Ophiostoma ulmi* (Buism.) Nannf. The three non-aggressive isolates stimulated significantly more mansonone E and F accumulation than the three aggressive isolates of *O. ulmi*. Mansonone induction also varied within both the aggressive and the non-aggressive groups. Aggressive and non-aggressive isolates were recovered in equal frequencies from the inoculation wounds, whereas the aggressive isolates were recovered more frequently than the non-aggressive isolates 15 cm and 25 cm up the seedlings' stem. Vascular browning in the outer xylem of the seedlings correlated with mansonone E and F accumulation.

Mansonone accumulation in *U. americana* seedlings is therefore associated with vascular browning and a reduction in fungal spread.

71. **Flannigan, M.D.; Harrington, J.B. 1988. A study of relation of meteorological variables to monthly provincial area burned by wildfire in Canada (1953-80). J. Appl. Meteorol. 27:441-452.**

The relation between meteorological variables and the monthly area burned by wildfire from May to August 1953-80 in nine Canadian "provinces" was investigated. A purely statistical approach to estimating the monthly provincial area burned, using meteorological variables as predictors, succeeded in explaining 30% of the variance west of Lake Nipigon and about 11% east of Lake Nipigon.

Long sequences of days with less than 1.5 mm of rain or days with relative humidities less than 60% proved to have the highest correlation with area burned. These long sequences were assumed to be associated with blocking highs in the westerlies.

Bad fire months were independent of rainfall amount but significantly dependent on rainfall frequency, temperature, and relative humidity.

72. **Flannigan, M.D.; Litwin, P.J. 1989. Mesure de l'humidité relative pour l'évaluation des risques d'incendie au Canada. PI-X-93F.**

Les températures des thermomètres secs et mouillés, installés dans des abris ventilés et non ventilés, peuvent servir à obtenir des valeurs réalistes de l'humidité relative à condition que le coefficient psychrométrique indiqué soit utilisé. Toutefois, les valeurs obtenues dans le cas des abris non ventilés peuvent être considérablement erronées lorsque le temps est ensoleillé ou calme.

Les recherches effectuées par les auteurs ont permis de constater que, pour mesurer l'humidité relative sur le terrain, les thermohygromètres ne donnaient pas de bons résultats, au contraire du bon fonctionnement du détecteur PCRC-11 et du dispositif Vaisala.

Il faudrait effectuer une étude sur la sensibilité de l'indice forêt-météo en ce qui concerne l'humidité relative. Les auteurs proposent de remplacer les tables des valeurs de l'humidité relative par l'équation Goff-Gratch. Enfin, d'autres solutions devraient être étudiées, comme l'application de la température du point de rosée pour obtenir l'humidité relative ou bien l'automatisation du système.

73. **Flannigan, M.D.; Litwin, P.J. 1989. Relative humidity measurement for fire danger rating in Canada. PI-X-93.**

Wet and dry bulb temperatures from ventilated and non-ventilated screens can be used to obtain realistic values of relative humidity provided the appropriate psychrometric coefficient is used. However, relative humidity from non-ventilated screens is subject to significant error when the weather is sunny or calm.

Investigations revealed that thermohygrometers are poor for field measurement of RH whereas the PCRC-11 sensor and Vaisala humicap performed well.

There is a need for a sensitivity study of the Fire Weather Index with respect to relative humidity. The authors suggest the relative humidity lookup table be replaced by the Goff-Gratch equation. Finally, alternatives like using dewpoint temperature to obtain relative humidity or automating the system should be investigated.

74. Flannigan, M.D.; Lynham, T.J.; Ward, P.C. 1989. An extensive blowdown occurrence in Northwestern Ontario. Pages 65-71 *in* MacIver, D.C., et al., eds. Proc. 10th Conf. Fire and Forest Meteorol., April, 17-21, 1989, Ottawa.

Severe surface winds were experienced in eastern Manitoba and northwestern Ontario in the evening and overnight on June 24-25, 1988. Four general areas of forest blowdown occurred in northwestern Ontario. Within each general area, contiguous areas of blowdown ranging from a few hectares to over a thousand hectares were observed. Isolated occurrences of private property damage were reported, but the main areas of blowdown were sparsely populated.

The cause of the severe surface winds was investigated using meteorological data from the period June 23-26, 1988. It was found that a vigorous cold front, associated with a fast moving low pressure system, provided the mechanism for higher wind speeds aloft to reach the surface. The high wind speeds aloft were associated with an upper level jet stream over the region.

These blowdown areas are of serious concern to fire managers in the region. Very heavy coniferous fuel loadings were concentrated on the blowdown sites, with a large proportion of fine aerial fuels. As the downed material cures, an increasing amount will be available for combustion. The fuel arrangement will also hamper conventional ground attack should a fire occur. A similar, but more extensive blowdown occurred in the same region in 1973 and was followed by a wildfire in 1974 that burned 32 000 hectares of blowdown fuel.

Dans la soirée du 24 juin 1988 et la nuit du 24 et 25, de violents vents de surface ont sévi dans l'est du Manitoba et la nord-ouest de l'Ontario. Dans cette dernière région, il y a eu quatre zones générales d'abattage d'arbres par le vent. Dans chacune des régions générales, on a observé des zones contiguës d'abattage par le vent, allant de quelques hectares à plus de 1 000 hectares. On a signalé des cas isolés de dégâts aux biens privés, mais, heureusement, les principales zones d'abattage par le vent n'étaient que peu peuplées.

On a étudié la cause des vents violents de surface, en utilisant les données météorologiques disponibles de la période allant du 23 au 26 juin 1988. On a constaté qu'un front froid vigoureux, lié au système de basse pression à déplacement rapide, a fourni le mécanisme suivant lequel des vents de vitesse élevées, en altitude, sont parvenus à la surface. Ces vents étaient liés à un courant-jet de haute altitude qui soufflait au-dessus de la région.

Ces zones d'abattage préoccupent beaucoup les responsables de la lutte contre l'incendie de la région. De très fortes charges de combustibles de conifères sont concentrées dans les lieux d'abattage, ainsi qu'une grande proportion de fins combustibles aériens légers. Quand les matériaux abattus seront secs, il y aura une quantité d'autant plus importante disponible pour la combustion. La disposition des combustibles rendra aussi très difficile la lutte classique au sol, si un incendie avait lieu. Un cas analogue de vaste abattage par le vent, survenu dans la même région en 1973, fut suivi, en 1974, par un feu de friches qui a brûlé 32 000 hectares de combustibles en majeure partie abattus par le vent.

75. Flannigan, M.D.; Wotton, B.M. 1989. A study of interpolation methods for forest fire danger rating in Canada. Can. J. For. Res. 19:1059-1066.

Canadian fire control agencies use either simple interpolation methods or none at all in estimating fire danger between weather stations. The authors compare several methods of interpolation and use the fire weather index in the North Central Region of Ontario as a case study. Their work showed that the second order least square polynomial, the smoothed cubic spline, and the weighted interpolations had the lowest residual sum of squares in our verification scheme. These methods fit the observed data at both high and low fire weather index values. The highly variable nature of the spatial distribution of

summer precipitation amount is the biggest problem in interpolating between stations. This factor leads to highly variable fire weather index fields that are the most difficult to interpolate. The use of radar and (or) satellite data could help resolve precipitation patterns with greater precision. These interpolation methods could easily be implemented by fire control agencies to gain a better understanding of fire danger in the region.

Les organismes canadiens de protection contre les feux de forêt n'utilisent aucune méthode sinon des méthodes simples d'extrapolation pour évaluer les risques de feu entre les stations météorologiques. On a comparé plusieurs méthodes d'extrapolation et utilisé l'indice forêt-météo dans le centre-nord de l'Ontario à titre d'exemple. Cet étude montre que les extrapolations au moyen d'un polynome du second degré utilisant les moindres carrés, d'une languette cubique flexible, et d'une pondération produisaient les sommes des carrés résiduelles les plus faibles selon notre procédure de vérification. Ces méthodes correspondent aux valeurs observées de l'indice forêt-météo autant élevé que faible. La très grande variation dans la distribution spatiale de la quantité de précipitation estivale est l'obstacle le plus important pour extrapoler entre les stations. Ce facteur entraîne une très grande variabilité dans les indices forêt-météo qui deviennent très difficiles à extrapoler. L'utilisation du radar ou des données satellite permettrait de connaître la distribution des précipitations avec une plus grande précision. Ces méthodes d'extrapolation pourraient facilement être adoptées par les organismes de protection contre les feux de forêt pour obtenir une meilleure estimation des risques de feu dans la région.

76. Fogal, W.H. 1989. Seed counts and cone insect foraging damage in relation to cone-collection date and stand type in white spruce. Pages 161-166 *in* Proc. 3rd IUFRO Cone and Seed Insects Working Party Conference, June 26-30, 1988, Victoria, B.C.

White spruce [*Picea glauca* (Moench) Voss.] cones were sampled at periodic intervals until cone maturation (June 4 to July 30) in three different stand types (plantations, open stands, mixed stands) to find (a) the most appropriate time to assess cones for determining sound seed yields and identifying insect damage, and (b) to assess the influence of stand type on cone insect foraging activities and production of sound seeds. For three of the most destructive insects, damage to cones reached a maximum early or midway through the sampling period and, thereafter, declined. The number of sound seeds decreased steadily over the course of the summer but appeared to reach a minimum level by mid-July. Some insects are more sensitive than others to stand type.

Des cônes d'épinette blanche [*Picea glauca* (Moench) Voss.] ont été prélevés à des intervalles réguliers jusqu'à ce qu'ils soient matures (du 4 juin au 30 juillet) dans trois types différents de peuplements (plantations, peuplements clairs et peuplements mixtes). On voulait déterminer le moment d'évaluation des cônes le plus approprié pour l'établissement du rendement en graines saines ainsi que l'appréciation des dommages causés par les insectes et étudier l'influence du type de peuplement sur l'activité alimentaire d'insectes déprédateurs des cônes et la production de graines saines. Les dommages causés aux cônes par les insectes ont atteint un maximum au début ou au milieu de la période de prélèvement des cônes et ont diminué par la suite pour trois des insectes les plus destructeurs. Le nombre de graines saines a diminué de façon constante pendant l'été, mais a semblé atteindre un niveau minimal vers la mi-juillet. Certains insectes ont été trouvés sensibles au type de peuplement, d'autres, non.

77. Fogal, W.H. 1989. White spruce cone crops in relation to seed yields, cone insect damage, and seed moth populations. Pages 76-88 *in* West, R.J., ed. 1989. Proc. Cone and Seed Pest Workshop, St. John's, Nfld., 4 Oct. 1989. For. Can. Inf. Rep. N-X-274.

Cone crop size, seed counts per cone, and the proportion of cones damaged by several insects, along with adult abundance, larval mortality, and diapause of the spruce seed moth, were monitored in white spruce stands for several years. The number of sound seeds per cone was positively correlated with the size of the cone crop, whereas the proportion of cones damaged by insects was negatively correlated

with the cone crop. The abundance of adult seed moths and the size of the cone crop were not correlated, whereas overwintering mortality and prolonged diapause were correlated with crop size. Summer temperatures influenced seed moth mortality and may have influenced prolonged diapause and cone crop size the following year.

Durant plusieurs années, dans des peuplements d'épinette blanche, on a enregistré le volume des cônes récoltés, le nombre de graines par cône et la proportion de cônes endommagés par divers insectes, de même que l'abondance d'adultes de la tordeuse des graines de l'épinette, la mortalité larvaire et la durée de leur diapause. Le nombre de graines saines par cône et le volume de cônes récolté ont été corrélés positivement, alors que la proportion de cônes endommagés par les insectes et le volume de cônes récoltés l'ont négativement. On n'a pas corrélé l'abondance de la tordeuse adulte avec le volume de la récolte, alors que la mortalité hivernale et la diapause prolongée ont été corrélées avec le volume de la récolte. Les températures estivales ont contribué à la mortalité de la tordeuse et peuvent avoir influencé la durée de la diapause et le volume de cônes récoltés l'année suivante.

78. Fogal, W.H.; Alemdag, I.S. 1989. Estimating sound seeds per cone in white spruce. For. Chron. 65:266-270.

White spruce cones were collected near Petawawa, Sudbury, and Oakville, Ontario during the 1982 and 1984 crop years. Cones were used to examine several regression models for estimating the number of sound seeds per cone as a function of seeds per cone section, cone length, and/or diameter. For the simplest models, using only one independent variable, highest coefficients of determination (R^2) were found with sound seed per section. A multiple regression model, including all three independent variables and their interactions, was identified. It provided higher coefficients of determination than the model using sound seed per cone section as a single independent variable but did not provide much more precision for estimating sound seeds per cone. Regressions were specific for locations and crop years.

Des cônes d'épinette blanche ont été cueillis près de Petawawa, de Sudbury et d'Oakville, en Ontario, au cours des années semencières 1982 et 1984. Ces cônes ont servi à l'examen de plusieurs modèles de régression permettant d'estimer le nombre de graines saines par cône en fonction des graines par section de cône, de la longueur des cônes ou du diamètre de ceux-ci. Dans le cas des modèles les plus simples n'utilisant qu'une seule variable indépendante, les coefficients de détermination (R^2) les plus élevés ont été obtenus pour le modèle reposant sur le nombre de graines saines par section. Un modèle de régression multiple intégrant les trois variables indépendantes ainsi que leurs interactions a donné des coefficients de détermination plus élevés que ce modèle, mais il n'apportait pas une précision beaucoup plus élevée. Les régressions sont spécifiques aux endroits et aux années de récolte.

79. Fogal, W.H.; Lopushanski. S.M. 1988. Prototype equipment for soil incorporating granular and liquid formulations of insecticides in conifer seed stands. Proc. Entomol. Soc. Ont. 119:79-81.

Application of water by sprinkler irrigation to help dissolve granules enhanced insect control and further reduced the risk to birds and sprinkling a liquid formulation was better than a granular formulation for control of cone insects on red pine *P. resinosa* Ait. The authors describe equipment that they have used to compare incorporation of granular and liquid formulations of carbofuran into soil for control of insects on seed trees of black spruce *Picea mariana* (Mill.) B.S.P. (Coniferae: Pinaceae) in small experimental plots.

80. Fogal, W.H.; Lopushanski, S.M. 1989. Stem incorporation of systemic insecticides to protect white spruce seed trees. For. Chron. 65:359-364.

White spruce trees were injected with a liquid formulation of dicrotophos (0.6 g AI/cm DBH) to evaluate the effect of injection times on cone and seed damage by insects. Injections of liquid

formulations of dicrotophos (1.1 g AI/cm DBH) and oxydemetonmethyl (0.7 g AI/cm DBH) (approximately four days after the peak of flowering) were evaluated for control of defoliation and cone and seed damage by insects. Implants of a soluble powder formulation of acephate (0.5 and 1.0 g AI/cm DBH) (approximately two weeks after the peak of flowering) were evaluated for control of cone and seed damage. A single injection of dicrotophos reduced cone damage for up to four weeks after the peak of flowering by insects that oviposit and feed after pollination (seed moth, cone maggot, cone-axis midge, and seed inhabitants) whereas damage by insects that begin feeding before pollination was not reduced by single injections after pollination. Dicrotophos and oxydemetonmethyl reduced defoliation by spruce budworm at upper, middle, and lower crown levels for two seasons following injection. In the treatment year, these injections reduced the proportions of cones damaged by insects that feed after pollination whereas damage by insects that feed before pollination was not reduced; cone seed counts were increased 558% by dicrotophos and 267% by oxydemetonmethyl. In the season after injection the proportion of cones damaged by budworm was reduced by both insecticides while seed inhabitant damage was reduced by dicrotophos. Neither insecticide reduced damage by other insects; nonetheless, cone seed counts were increased 90% by dicrotophos and 115% by oxydemetonmethyl. In the year of treatment, implants of acephate reduced the proportions of cones damaged by seedmoth but not other insects whereas, in the season after implanting, they were effective against coneworm, seed moth, cone maggot, and seed inhabitants.

On a injecté dans des épinettes blanches une préparation liquide de dictrotophos (à raison de 0,6 g d'ingrédient actif par cm du diamètre à hauteur de poitrine) pour évaluer l'effet du moment de l'injection sur les dommages causés aux cônes et aux graines par les insectes. Les effets des préparations liquides de dicrotophos (1,1 g d'ingrédient actif par cm du diamètre à hauteur de pointrine) et d'oxydémétonméthyle (0,7 g d'ingrédient actif par cm du diamètre à hauteur de poitrine) injectées quatre jours après l'apogée de la floraison ont été évalués afin de déterminer dans quelle mesure de défoliation et les dommages aux cônes et aux graines causés par les insectes avaient diminué. Les effets d'implants d'une préparation d'acéphate en poudre soluble (0,5 et 1,0 g d'ingrédient actif par cm du diamètre à hauteur de poitrine) introduits environ deux semaines après l'apogée de la floraison ont été évolués pour savoir si les dommages causés aux cônes et aux graines diminueraient. Pour une période allant jusqu'à quatres semaines après l'apogée de la floraison, une seule injection de dicrotophos a eu pour effet de réduire les dommages causés aux cônes par les insectes qui pondent des oeufs et se nourissent après la pollination (la mouche granivore, la cécidomyie et les insectes qui vivent dans les graines). Cependant, les dommages causés par les insectes qui commencent à se nourrir avant la pollination n'ont pas été réduits par des injections uniques après la pollination. Le dicrotophos et l'oxydéméthonméthyle ont réduit, pendant deux saisons après les injections, la défoliation causée par la tordeuse des bourgeons de l'épinette dans le haut, le milieu et le bas de la cime. Au cours de l'année de traitement, ces injections ont réduit la proportion des cônes endommagés par les insectes qui se nourissent après la pollination, alors que les dommages causés par les insectes qui se nourissent avant la pollination n'ont pas diminué. Le nombre de graines dans les cônes a augmenté de 558 % avec le dicrotophos, et de 267 % avec l'oxydémétonméthyle. Pendant la saison suivant les injections, la proportion de cônes endommagés par la tordeuse des bourgeons a été réduite par les deux insecticides, tandis que le dicrotophos a permis de diminuer les dommages causés par les insectes qui vivent dans des graines. Aucun des deux insecticides n'a pu réduire les dommages causés par d'autres insectes, mais le nombre de graines dans les cônes a augmenté de 90 % avec le dicrotophos et de 115 % avec l'oxydémétonméthyle. Au cours de l'année de traitement, les implants d'acéphate ont permis de réduire la proportion des cônes endommagés par la tordeuse sémimivore, mais non par d'autres insectes, toutefois, pendant la saison suivant l'introduction d'implants, ces derniers ont été efficaces contre la pyrale des cônes, la tordeuse sémimivore, la mouche granivore et les insectes qui vivent dans les graines.

81. Fogal, W.H.; Lopushanski, S.M.; MacLeod, D.A.; Winston, D.A. 1988. Soil incorporation of carbofuran for protecting black spruce seed trees from insects. Proc. Entomol. Soc. Ont. 119:69-78.

Carbofuran was applied to black spruce, *Picea mariana* (Mill.) B.S.P., seed trees by soil incorporation of granular and liquid formulations at rates of 5 or 10 g of active ingredient per cm diameter at breast height (AI/cm DBH). Numbers of spruce budworm, *Choristoneura fumiferana* (Clem), and spruce coneworm, *Dioryctria reniculelloides* Mutuura and Munro, degree of defoliation, cone production, percentage of cones damaged by seed and cone insects, numbers of sound seeds per cone slice, numbers of female buds per branch from the cone-bearing portion of the tree, and phytotoxicity were assessed in the year of treatment and one year later. The liquid formulation effectively controlled budworm in the year of treatment and the year after, granular carbofuran was not effective in the year of treatment, but it was effective the following year. Treatments were effective at upper, middle, and lower crown positions. They had no detectable influence on cone yields or cone damage by insects but cone seed counts were increased by the liquid formulation at 5 g AI/cm DBH in the year after treatment. Treatments did not influence initiation of female cone buds. Phytotoxic stress was evident at the 10 g AI/cm DBH liquid formulation in the second year of assessment but not at the 5 gAI/cm DBH.

82. Fogal, W.H.; Plowman, V.C. 1989. Systemic insecticides for protecting northern spruce and pine seed trees. PI-X-92.

Control of cone and seed insects on white spruce [*Picea glauca* (Moench) Voss], black spruce [*Picea mariana* (Mill.) B.S.P.], red pine (*Pinus resinosa* Ait.), and eastern white pine (*Pinus strobus* L.) is possible with systemic insecticides applied to crowns in three ways: with hydraulic sprayers or mist blowers, incorporated into stems by injection or implant, or incorporated into soil in a granular or liquid form. Field trials have been conducted with acephate, carbofuran, dicrotophos, dimethoate, formothion, methomyl, oxydemetonmethyl, and phorate. Dimethoate is registered for use in Canada as a crown hydraulic spray on spruces. Carbofuran is registered in the U.S.A. for northern pines by incorporating granules into soil. While treatments reduce the frequency of insect-damaged cones, they do not always provide increases in seed yield. Insect feeding behaviour, uptake, translocation and metabolism of insecticides, losses of seeds and cones to factors other than insects, and the size of the cone crop are critical factors influencing the efficacy of insecticide treatments.

83. Fogal, W.H.; Plowman, V.C. 1990. Insecticides systémiques servant à la protection des épinettes et des pins semenciers du nord. PI-X-92F.

Il est possible de lutter contre les insectes qui nuisent aux cônes et aux graines de l'épinette blanche [*Picea glauca* (Moench) Voss], de l'épinette noire [*Picea mariana* (Mill.) B.S.P.], du pin rouge (*Pinus resinosa* Ait.) et du pin blanc (*Pinus strobus* L.) à l'aide des insecticides systémiques appliqués de trois façons dans le houppier: par pulvérisation à l'aide d'un appareil à pression de liquide ou d'un nébulisateur; par injection ou implantation dans la tige; ou par incorporation dans le sol sous forme granulaire ou liquide. Des essais sur le terrain ont été effectués avec les insecticides suivants: acéphate, carbofuran, dicrotophos, diméthoate, formothion, méthomyl, oxydéméton-méthyle et phorate. Le diméthoate est homologué au Canada pour utilisation sur les épinettes par pulvérisation à pression de liquide. Le carbofuran est homologué aux États-Unis pour utilisation sur les pins du Nord par incorporation de granulés dans le sol. Même si les traitements permettent de réduire la fréquence des dommages causés aux cônes par les insectes, ils n'assurent pas toujours une augmentation du rendement en graines. Le comportement d'alimentation des insectes, l'ingestion, la translocation et le métabolisme des insecticides, les pertes de graines et de cônes dues à des facteurs autres que les insectes ainsi que l'importance de la récolte de cônes sont des facteurs critiques relativement à l'efficacité des traitements insecticides.

84. Forestry Canada/Forêts Canada. 1989. Petawawa Research Forest. Headquarters Silvicultural Area/La Forêt expérimentale de Petawawa. La zone de sylviculture de l'Administration centrale. Pamphlet/Brochure.

85. Forestry Canada/Forêts Canada. 1989. Petawawa Research Forest. Users' map/La Forêt expérimentale de Petawawa. Carte de démonstration. Pamphlet/Brochure.

86. Gabard, J.M.; Charest, P.J.; Iyer, V.N.; Miki, B.L. 1989. Cross-resistance to short residual sulfonylurea herbicides in transgenic tobacco plants. Plant Physiol. 91:574-580.

Transgenic *Nicotiana tabacum* plants, produced by *Agrobacterium tumefaciens*-mediated transformation with a mutant gene (*csr1-1*) coding for acetohydroxyacid synthase (AHAS) from a chlorsulfuron resistant *Arabidopsis thaliana* line GH50 (GW Haughn et al. [1988] Mol Gen Genet 211: 266-271; GW Haughn, C Somerville [1986] Mol Gen Genet 204: 430-434), were selected directly on 80 micrograms per liter (225 nanomolar) chlorsulfuron. The expression of *csr-1* in two separate transgenic lines CHL-1 and CHL-2 was confirmed by biochemical and genetic analyses. The AHAS activity of GH50 and the equivalent component of AHAS activity in CHL-2 was resistant to three short residual sulfonylurea herbicides, DPX-M6316, DPX-A7881, and DPX-L5300, in addition to chlorsulfuron but not to the sulfonylurea CGA 131'036. Cross-resistance to the imidazolinones AC 263, 499, AC 252, 214, and AC 243, 997 was not observed. Parallel observations were made on the inhibition of seedling growth in soil or on culture medium. The relevance of these findings for the application of transgenic plants in agriculture is discussed.

87. Gillis, M.D. 1988. Estimating change from successive static forest inventories. For. Chron. 64:352-354.

Most Canadian forest inventories are designed to obtain information about forest resources at a specific point in time, i.e., static information. In recent years there has emerged a requirement for information on changes over time of the forest resource. One potential for getting such information is to compare data from successive (static) inventories. However, as shown in this paper, such changes are frequently artifacts of different procedures. Because real changes in forest resources may be masked by artificial differences, such comparison is discouraged and should not be done without detailed background knowledge.

La plupart des inventaires forestiers canadiens sont conçus pour obtenir le portrait des ressources forestières à un moment précis dans le temps, une information ponctuelle. Ces dernières années, on a senti le besoin d'obtenir des données sur l'évolution de ces ressources. L'un des moyens d'obtenir cette information, c'est de comparer les données des inventaires ponctuels successifs. Toutefois, comme il est démontré dans ce document, cette comparaison est souvent faussée par les différences de méthodes employées dans chaque inventaire. Puisque l'évolution réelle des ressources forestières peut être masquée par des différences artificielles, il est déconseillé de procéder à ces comparaisons à moins de bien connaître la méthodologie de chaque inventaire.

88. Gillis, M. 1988. Gaps in Canada's Forest Inventory. PI-X-78.

There are some areas of productive forest in Canada not yet covered by forest inventory programs. These gaps occur in transition forest of generally low current commercial value. Sampling was carried out in the Alberta and Saskatchewan gaps to provide broad but statistically objective estimates of area and volume for Canada's forest inventory. A network of photo plots was established in each gap. Plots were described by photo interpretation according to 1986 national inventory codes. Volume estimates were interpreted for the stocked productive forest plots. The sample was calibrated with a regression estimator using a subsample of ground plots.

The 5 250 000 hectares of uninventoried productive forest land contains 409 140 810 m^3 of wood, of which 39% is in Alberta, 10% in southern Saskatchewan, and 51% in northern Saskatchewan.

89. Gillis, M. 1988. Zones non couvertes dans l'Inventaire des forêts du Canada. PI-X-78F.

Certaines régions forestières productives du Canada ne font pas encore l'objet de programmes d'inventaire forestier. Elles sont situées dans la zone forestière de transition composée d'essences ayant généralement une faible valeur commerciale actuelle. Des activités d'échantillonnage ont été effectuées dans les régions non inventoriées de l'Alberta et de la Saskatchewan afin d'obtenir des estimations générales, mais statistiquement objectives de leur superficie et de leur volume pour l'inventaire des forêts du Canada. Un réseau de photoplacettes a été établi dans chaque région non inventoriée. Chaque placette a été décrite grâce à la photo-interprétation à l'aide des codes de l'inventaire des forêts du Canada de 1986. Les estimations de volume ont été interprétées dans les placettes forestières boisées productives. L'échantillon a été calibré à l'aide d'un estimateur de régression grâce à un sous-échantillon de placettes au sol.

Les 5 250 000 hectares de terres forestières boisées productives et non inventoriées renferment 409 140 810 m^3 de bois dont 39 % est situé en Alberta, 10 % dans le sud de la Saskatchewan et 51 % dans le nord de la Saskatchewan.

90. Gillis, M.D.; Edwards, J.A. 1988. Volume compilation procedures in forest management inventories. PI-X-79.

Forest inventory compilation procedures and the application of inventory estimates arising from the compilations have not been described in the literature. To fill this gap a survey of provincial and territorial compilation procedures was undertaken, and a common forest inventory process, or model, emerged.

This report describes components of the model and lists characteristics of provincial inventory procedures as they relate to the model. Weaknesses associated with the inventory process relate more to the understanding and application of the model than to the individual components. The main problems are associated with the sequencing of components, photo interpretation, the establishment of sample units, and the application of single tree equations. Although the individual components of the model are likely to change in the future the basic compilation process is expected to remain valid. An example of a forest inventory procedure is contained in an appendix.

Les méthodes d'inventaire forestier et l'application des résultats obtenus à l'aide de ces inventaires n'ont pas été décrites dans les publications. Pour combler cette lacune, une étude des méthodes utilisées dans les provinces et les territoires a été entreprise, et il s'en est dégagé un processus, ou un modèle, commun d'inventaire forestier.

Le rapport décrit les éléments du modèle et énumère les caractéristiques des méthodes provinciales d'inventaire qui sont en rapport avec le modèle. Les lacunes du processus d'inventaire ont trait à la compréhension et à l'application du modèle plutôt qu'aux éléments individuels. Les principaux problèmes concernent la mise en séquence des éléments, l'interprétation des photographies, l'établissement d'unités d'échantillons et l'application d'équations pour les arbres pris individuellement. Il est probable que les éléments individuels du modèle changeront, mais on croit que le processus fondamental d'inventaire demeurera valide. Un exemple d'une méthode d'inventaire forestier est donné en annexe.

91. Gillis, M.D.; Pick, R.D.; Leckie, D.G. 1990. Satellite imagery assists in the assessment of hail damage for salvage harvest. For. Chron. 66:463-468.

On June 8, 1987 a severe thunderstorm caused extensive hail damage to portions of the forest within Algonquin Provincial Park, Ontario. The Algonquin Forestry Authority, charged with the responsibility for harvest operations within the Park, decided to salvage the damaged forest. A map of the damage was required to determine the area and volume to be harvested. A cooperative project between the Algonquin Forestry Authority and the Petawawa National Forestry Institute was established to map the damaged area by combining satellite imagery and existing ground information and to define the cut blocks using the satellite data as a guide for field work. A colour composite transparency of Landsat Thematic Mapper data was acquired and the damaged area mapped in just over two weeks. The satellite imagery in combination with ground work provided a simple, effective, and timely method for assessing hail storm damage for an operational salvage harvest.

Le 8 juin 1987, un violent orage, accompagné de grêle, a causé des dommages importants dans des parties de la forêt du parc provincial Algonquin. L'Agence de foresterie du parc Algonquin, chargés des opérations de coupe dans le parc, a décidé de récupérer les arbres endommagés. Elle avait besoin d'une carte des dommages pour déterminer l'emplacement et le volume des coupes à effectuer. Il s'est donc associé à une équipe de l'Institut forestier national de Petawawa afin d'établir une telle carte à l'aide d'images satellite et des données de terrain existantes et de délimiter les blocs de coupe en utilisant les données satellite comme guide pour les travaux sur le terrain. Une image en composition colorée produite à partir des données du *Thematic Mapper* de Landsat a été obtenue, et les zones de dommages ont pu être cartographiées en juste deux semaines. Les images de Landsat, combinées aux données de terrain, ont offert un moyen simple, efficace et rapide d'évaluer les dommages causés par la grêle en vue d'une coupe de récupération.

92. Gougeon, F.A.; Moore, T. 1988. Individual tree classification using MEIS-II imagery. Page 927 *in* Proc. of IGARSS '88 Symp., Edinburgh, Scotland, 13-16 Sept., 1988.

Very high spatial resolution digital images obtained from airborne sensors such as the Multi-detector Electro-optical Imaging Scanner (MEIS) are difficult to analyze for forestry purposes using conventional numerical classification methods. The detail is such that, within a given image area, some pixels correspond to the lighted sides of trees, others to the shaded sides, and others to the understorey. Although such detailed information is welcome for analysis enhanced images by photo-interpretation, it creates inhomogeneities that increase variabilities of spectral signatures beyond those suitable for good numerical analyses by conventional methods. In this paper, we decrease this variability by the sequential use of two masks. Our method leads to improved classification results.

93. Gougeon, F.A.; Moore, T. 1989. Classification individuelle des arbres à partir d'images à haute résolution spatiale. Pages 185-196 *in* Gagnon et collab., 1989. Télédétection et gestion des ressources. Vol. 6. Comptes rendus du 6e congrès de l'Association québécoise de télédétection, Sherbrooke, Québec, 4-6 mai 1988.

La haute résolution spatiale des images des détecteurs numériques aéroportés présente certains problèmes aux méthodes de classification conventionnelles. Celles-ci classifient chaque pixel indépendemment, et sont basées sur l'utilisation de signatures spectrales qu'on assume être des distributions gaussiennes de radiances. Cette hypothèse devient de moins en moins valide au fur et à mesure que la résolution spatiale augmente. À haute résolution, une classification par objet (c.-à-d. arbre) est probablement plus appropriée.

Une approche simple a été développée qui permet de se servir malgré tout des méthodes conventionnelles de classification. Elle consiste à utiliser des masques qui ne laissent passer que les données multispectrales représentant le côté illuminé ou le faîte des arbres des espèces principales. Cette approche améliore les classifications forestières des données du détecteur aéroporté MEIS-II.

The high spatial resolution of images from digital airborne multispectral sensors presents various problems to the conventional classification methods. These methods classify every pixel independently and are based on the use of spectral signatures for which Gaussian distributions of pixel radiances are assumed. This hypothesis becomes less and less valid as the spatial resolution of multispectral imagery is increased. At high resolution, an object-based classification (i.e. by trees) is probably more appropriate.

A simple approach which still allow us to use conventional classification methods was developed. It consists of using masks which allow only the multispectral data from the lighted side or the top of the major species' trees to be utilized. This approach improves forestry classifications of data from the MEIS-II airborne sensor.

94. Grant, G.G.; Fogal, W.H.; West, R.J.; Slessor, K.N.; Miller, G.E. 1989. A sex attractant for the spruce seed moth, *Cydia strobilella* (L.), and the effect of lure dosage and trap height on capture of male moths. Can. Ent. 121:691-697.

Electroantennogram (EAG) responses from male *Cydia strobilella* (L.) indicated that (E)-8-dodecenyl acetate (E8-12:Ac) was the most stimulating of the dodecenyl and tetradecenyl compounds assayed. Field-screening tests, which included compounds previously reported as attractive, demonstrated that only E8-12:Ac was effective. The optimum trap dosage was 0.3-3 µg on red rubber septa. Catches of males were greater when traps were hung in the upper crown of either white spruce or black spruce.

Les réactions électroantennographiques (EAG) des mâles de *Cydia strobilella* (L.) ont indiqué que le (E)-8-dodécenyl acétate (E8-12:Ac) est le plus stimulant des composés dodécenylés et tétradécenylés testés. Des tests de terrain avec des composés rapportés antérieurement comme attractifs, ont démontré que seul le E8-12:Ac est efficace. La dose optimale était de 0.3-3 µg sur septum de caoutchouc rouge. Les captures de mâles étaient plus élevées lorsque les pièges étaient suspendus dans la couronne supérieure que dans la partie inférieure, à la fois pour l'épinette blanche et l'épinette noire.

95. Gray, S.L.; Nietmann, K. 1989. Canada's Forest Inventory 1986 - technical supplement. PI-X-86.

Canada's forest inventory 1986 is a base for strategic decision-making as well as being background information. The report describes source data for Canada's forest inventory 1986, how they were compiled, and gives precautions for proper use. Data summaries and maps are reported in separate publications.

The inventory coverage has improved since the last Canada-wide inventory (1981) and now includes all significant forestry areas. The result is the most up-to-date wood volume information for Canada as of 1986. A special feature of these forestry data is that they are available by 43 172 geographic units, most of which are about 100 km^2. These kinds of spatially detailed data can then be combined with other spatially referenced data.

The information is up to 40 years old (1946) and on average is 10 years old (1976). The data consist of area and volume statistics by up to 12 classifiers. The volume data are available for up to 19 species groups for pulpwood and sawwood utilization specifications. Age class, predominant genus, sawwood volumes, cull factors to give net volumes, policy constraint, productivity, and tree size-volume

relationship are new since the last inventory. Several other refinements are introduced, especially an improved handling of missing values and stocking. Not all classifiers and classes are available from every source inventory.

L'Inventaire des forêts du Canada 1986 est une base de décision stratégique et un document de référence. Dans le rapport, on explique d'où viennent les données qui ont servi à la préparation de l'inventaire, comment elles ont été compilées et de quelle façon il faut s'en servir. Les sommaires et les cartes font l'objet de publications séparées.

Par comparaison à l'inventaire national de 1981, les données sont plus complètes : toutes les régions forestières d'importance sont maintenant inventoriées. Le produit final est un recueil de renseignements le plus à jour possible en 1986 sur les volumes de bois du Canada. L'un des intérêts particuliers de ces données de foresterie vient de ce qu'elles se présentent par unités géographiques dont la plupart mesurent environ 100 km^2 de superficie : on compte en tout 43 172 unités. En raison de leur caractère géographique détaillé, ces données peuvent se combiner à d'autres données également caractérisées géographiquement.

Les renseignements fournis peuvent dater de 40 ans (1946), mais en moyenne ils datent de 10 ans (1976). Il s'agit de statistiques sur les superficies et les volumes dont le classement peut mettre en jeu jusqu'à 12 critères. On donne les volumes de bois de pâte et les volumes de bois d'oeuvre pour 19 groupes d'espèces. De nouveaux facteurs ont été ajoutés à ceux de l'inventaire précédent : classes d'âge, genre prédominant, volumes de bois d'oeuvre, taux de carie pour la détermination du volume net, contraintes découlant de la politique forestière, productivité et relations entre la taille de l'arbre et le volume. Il y a plusieurs autres améliorations, notamment en ce qui concerne le traitement des valeurs manquantes et de la densité relative. Les sources d'inventaire ne donnent pas toujours tous les classements.

96. Hall, R.B.; Burgess, D. 1990. Evaluation of *Alnus* species and hybrids. Biomass 22:21-34.

Trials of a common set of seed lots representing 39 parents and five species of *Alnus* have been started in four countries: Belgium, Canada, the UK, and the US. Initial results indicate that cold hardiness is a problem in using *A. acuminata* but that sufficiently hardy *A. rubra* sources are available. *A. glutinosa* had the best growth in the nursery, and *A. cordata* had the best survival under severe moisture-stress conditions. A summary also is given of a workshop on alder improvement that further demonstrates the potential for developing the genus for biomass energy production.

97. Hendrickson, O.Q. 1988. Biomass and nutrients in regenerating woody vegetation following whole-tree and conventional harvest in a northern mixed forest. Can. J. For. Res. 18:1427-1436.

Biomass and nutrient contents of regenerating woody plants and litter fall were measured after a northern mixed conifer - hardwood forest was harvested by conventional and whole-tree methods. Before harvest, the central Ontario study site was occupied by a 95-year-old pine (*Pinus resinosa, P. strobus*) and aspen (*Populus tremuloides, P. grandidentata*) stand growing on gently rolling, gravel-free outwash sands. Four years after harvest, aspen abundance increased 100-fold in both harvested areas, with higher densities after whole-tree harvest (WTH) (4.1 stems/m^2) than after conventional harvest (CH) (2.7 stems/m^2). No self-thinning of aspen occurred between 2 and 4 years after harvest. Total aboveground woody biomass accumulated at 2.0 $t \cdot ha^{-1} \cdot year^{-1}$ in the WTH area and 1.5 $t \cdot ha^{-1} \cdot year^{-1}$ in the CH area; the preharvest rate was 2.0 $t \cdot ha^{-1} \cdot year^{-1}$. Peak autumn litter production occurred earlier in the harvested areas than in an adjacent uncut area. Cycling of N and K in litter fall returned to preharvest rates after 4 years. Cycling of Ca in litter fall was lower after WTH than after CH. Vegetation uptake of N and K (litter fall plus woody biomass) in the harvested areas in year 4 exceeded the preharvest value. Increased N accumulation in woody biomass (3.0 $kg \cdot ha^{-1} \cdot year^{-1}$ before harvest, 10.6 $kg \cdot ha^{-1} \cdot year^{-1}$ after WTH) would place a relatively greater demand on forest floor N

pools in the WTH than in the CH area owing to lack of N input in logging slash. Although WTH did not reduce initial rates of biomass production, *Populus* spp. had lower concentrations of N, Ca, and Mg in the WTH area than in the CH area. There may be a danger that WTH on less fertile sites in the region will produce dense, unproductive aspen stands with low rates of self-thinning.

Le contenu en biomasse et en éléments nutritifs des plantes ligneuses en régénération et de la litière a été mesuré après la récolte d'un peuplement mixte de conifères et de feuillage faite suivant un procédé conventionnel et celui par arbres entiers. Avant la récolte, la station localisée dans le centre de l'Ontario était occupée par un peuplement de pins (*Pinus resinosa, P. strobus*) et de peupliers (*Populus tremuloides, P. grandidentata*) âgé de 95 ans et établi sur un outwash sableux dépourvu de gravier formant une topographie peu accidentée. Quatre ans après la récolte, l'abondance des peupliers s'était accrue de 100 fois dans les deux étendues récoltées, la densité de ceux-ci étant supérieure après le procédé par arbres entiers (4,1 tiges/m^2) qu'après le procédé conventionnel (2,7 tiges/m^2). Aucune éclaircie naturelle ne s'est produite avec les peupliers entre 2 et 4 ans après la récolte. La biomasse ligneuse totale au-dessus du sol s'est accumulée au taux de 2,0 $t \cdot ha^{-1} \cdot an^{-1}$ dans la coupe par arbres entiers et à celui de 1,5 $t \cdot ha^{-1} \cdot an^{-1}$ dans la coupe conventionnelle; le taux d'avant la récolte était de 2,0 $t \cdot ha^{-1} \cdot an^{-1}$. La production maximale de litière en automne est survenue plus tôt dans les étendues récoltées que dans le témoin non récolté adjacent. Le cyclage de N et de K dans la litière est revenu au niveau d'avant la coupe après 4 ans. Le cyclage de Ca dans la litière était plus faible après la coupe par arbres entiers qu'après la coupe conventionnelle. Le prélèvement par la végétation de N et K (litière et biomasse ligneuse) dans les étendues récoltées à l'année 4 a dépassé le niveau d'avant la coupe. L'accumulation accrue de N dans la biomasse ligneuse (3,0 $kg \cdot ha^{-1} \cdot an^{-1}$ avant la récolte, 10,6 $kg \cdot ha^{-1} \cdot an^{-1}$ après celle par arbres entiers) implique une demande quelque peu supérieure auprès du pool de N du parterre forestier avec la coupe par arbres entiers qu'avec le procédé conventionnel, par suite du manque d'apport de N dans les débris ligneux. Bien que la coupe par arbres entiers n'ait pas réduit le taux initial de production de biomasse, *Populus* spp. avaient de plus faibles concentrations de N, Ca et Mg dans l'étendue récoltée par arbres entiers que dans celle récoltée conventionnellement. Il existe un risque que la coupe par arbres entiers pratiquée dans des stations peu fertiles de la région produise des peuplements denses et improductifs de peupliers avec de faibles taux d'éclaircie naturelle.

98. Hendrickson, O.Q. 1988. Use of acetylene reduction for estimating nitrogen fixation in woody debris. Soil Sci. Soc. Am. J. 52:840-844.

Both endogenous C_2H_4 formation and C_2H_4 arising from reduction of C_2H_2 must be accurately measured in N_2 fixation studies using C_2H_2 reduction. Previous work with forest soil has shown that C_2H_4 formed in air is not an appropriate control for endogenous C_2H_4 formation. This study compared different controls for endogenous C_2H_4 formation during C_2H_2 reduction studies of woody logging debris. Amounts of C_2H_4 formed by decaying wood in the presence of C_2H_2 plus either of two noncompetitive inhibitors of C_2H_2 reduction (CO, $(NH_4)_2SO_4$) were greater ($p < 0.01$) than amounts of C_2H_4 formed in air. Ambient air controls therefore underestimated endogenous C_2H_4 formation, and would overestimate N_2 fixation rates. Controls using $(NH_4)_2SO_4$ were not suitable for routine use due to alteration of sample moisture content. With CO as an inhibitor, endogenous C_2H_4 formation averaged 23% of total C_2H_4 formed in the presence of C_2H_2 across a range of moisture contents. Field data on C_2H_4 produced by logging slash in the presence of C_2H_2 alone are discussed in light of these findings. In future, C_2H_2 reduction studies of N_2 fixation in decaying wood should employ CO controls for endogenous C_2H_4 formation.

99. Hendrickson, O.Q. 1989. Implication of natural ethylene cycling processes for forest soil acetylene reduction assays. Can. J. Microbiol. 35:713-718.

Under aerobic conditions, ethylene production and oxidation occurred simultaneously in organic and mineral horizons of a northern hardwood forest. Ethylene oxidation rates in mineral soil were high (up

to 25 nmol•g^{-1}•day^{-1}) relative to other forest soils, and exceeded production rates unless moisture contents were raised above saturation. Acetylene inhibits ethylene oxidation while allowing ethylene production to proceed; control samples for acetylene reduction assays should therefore contain acetylene plus a nitrogenase inhibitor such as carbon monoxide if forest soil nitrogenase activity is to be accurately quantified. A level of 7 kPa carbon monoxide gave complete nitrogenase inhibition in active forest floor samples in the presence of acetylene; carbon monoxide was applied 2 h in advance of acetylene to compensate for its lower solubility in water. Use of this methodology revealed a strong inhibitory effect of saturated water contents on forest floor acetylene reduction activity, suggesting that aerobic N_2-fixing activity predominated in unamended forest soil samples.

Dans des conditions aérobies, la production et l'oxydation de l'éthylène sont survenues simultanément dans les horizons oganiques et minéraux d'un sol nordique supportant une forêt d'arbres décidus. Dans les horizons minéraux, les taux d'oxydation de l'éthylène ont été élevés (jusqu'à 25 nmol•g^{-1}•$jour^{-1}$) comparativement à d'autres sols forestiers et ces taux ont excédé les taux de production, sauf lorsque l'humidité du sol atteignait une sursaturation. L'acétylène inhibe l'oxydation de l'éthylène, mais non la production d'éthylène; les échantillons témoins devraient donc contenir une certaine quantité d'acétylène ainsi qu'un inhibiteur de nitrogénase, comme le monoxyde de carbone, si l'activité de la nitrogénase d'un sol forestier doit être quantifiée de façon précise. Une concentration de monoxyde de carbone équivalente à 7 kPa a permis d'inhiber complètement la nitrogénase dans des échantillons forestiers d'horizons organiques actifs en présence d'acétylène; l'application du monoxyde de carbone a dû précéder de 2 h celle de l'acétylène pour compenser sa moindre solubilité aqueuse. Cette méthodologie a révélé que la saturation en eau des horizons organiques actifs des forêts avait un effet inhibiteur élevé sur la réduction de l'activité de l'acétylène, ce qui suggère que l'activité aérobie de fixation de l'azote a prédominé dans les échantillons de sols forestiers non amendés.

100. Hendrickson, O.Q. 1990. Asymbiotic nitrogen fixation and soil metabolism in three Ontario forests. Soil Biol. Biochem. 22:967-971.

Field and laboratory incubations were used to assess nitrogenase (acetylene reduction) activity, nitrogen mineralization, and respiration in three mature forests in the northern hardwoods - boreal transition zone of eastern North America. A 66-yr-old jack pine (*Pinus banksiana* Lamb.) forest had 45.4 t ha^{-1} of forest floor, ca 33% more than older mixedwood and hardwood forests in the same vicinity. Jack pine forest floor was more acid, mineralized only one-third as much N and half as much C during laboratory incubations, had little or no nitrogenase activity on eight sampling dates during the growing season, and contained 40- to 70-fold lower numbers of N_2-fixing bacteria. Low nutrient turnover in older jack pine stands may result in buildup of surface organic horizons and declining tree growth. At the moister hardwood site, temperature variations largely accounted for seasonal trends in C_2H_2 reduction; activity at the drier mixedwood site increased following rainfall events. Although asymbiotic N_2 fixation in surface soils is a small N input (<1 kg $ha^{-1}yr^{-1}$) compared to precipitation in these more productive northern forests, it may stimulate litter decay and N dynamics.

101. Hendrickson, O.Q. 1990. How does forestry influence atmospheric carbon? For. Chron. 66:469-472.

The author examines several approaches to studying the effects of forestry practices on the flux of carbon between forest ecosystems and the atmosphere. If the average live forest biomass carbon pool in mature uncut forests is greater than that in second-growth forests, harvesting causes a long-term loss of carbon to the atmosphere. However, in the short term, increased productivity of cut-over stands relative to comparable uncut stands implies a net carbon flux from the atmosphere to the biomass. Management also affects the return flux of carbon to the atmosphere from non-living pools: values for wood and paper products will differ from those for naturally decomposing materials. The greater the proportion of harvested biomass carbon retained in long-lived forest products, the smaller the increase in atmospheric carbon due to harvesting. Under sustainable management, carbon releases to the

atmosphere can also be reduced by use of wood biomass fuels, which displace non-renewable fossil fuels. Models combining growth and decay rates with estimates of major carbon pools will provide the best analyses of forest management impacts on the carbon balance.

Plusieurs approches sont examinées relativement à l'étude des effets des pratiques forestières sur le transfert du carbone entre les écosystèmes forestiers et l'atmosphère. Si le stock moyen de carbone dans la biomasse forestière vivante des forêts mûres sur pied dépasse celui des forêts de second venue, la récolte cause à long terme une perte de carbone vers l'atmosphère. À court terme, toutefois, en raison de la productivité supérieure des peuplements coupés par rapport aux peuplements sur pied comparables, il y a transfert net du carbone de l'atmosphère à la biomasse. L'aménagement influe sur le flux de retour à l'atmosphère du carbone emmagasiné dans les stocks non vivants; les valeurs pour les produits de bois et le papier sont différentes de celles des matières qui se décomposent naturellement. Plus la biomasse récoltée est transformée en produits à longue durée de vie, moindre est l'augmentation du carbone atmosphérique causée par la récolte. Dans le contexte d'une gestion viable, il est également possible de réduire le flux de carbone vers l'atmosphère par l'utilisation de la biomasse ligneuse comme combustible à la place des combustibles fossiles non renouvelables. Les modèles, tenant compte à la fois des taux de croissance et de décomposition ainsi que des estimations des principaux stocks de carbone, permettent de mieux analyser les répercussions des pratiques d'aménagement des forêts sur le bilan du carbone.

102. Hendrickson, O.Q. 1990. Nitrogen availability and decline in white spruce plantations. Pages 67-73 *in* B.D. Titus, et al., eds. The Silvics and Ecology of Boreal Spruces. 1989 IUFRO Working Party S1.05-12 Symp. Proc., Newfoundland, 12-17 Aug. 1989. For. Can. Inf. Rep. N-X-271.

Increment cores were obtained from five apparently healthy dominant white spruce (*Picea glauca* (Moench) Voss) trees in each of 37 permanent sample plots in plantations established at the Petawawa National Forestry Institute between 1924 and 1940. The difference between mean annual basal area increment for 1973-1987 and for 1958-1972, used as an index of relative growth or decline, ranged from -7.4 to 3.6 cm^2yr^1, with a mean of -1.8 cm^2yr^1. This index was positively correlated ($R = 0.473$, $p<.005$) with NH_4-N formation in mineral soil (0-15 cm), assayed using 6-week aerobic incubations at 30°C. Growth decline was most evident where NH_4-N production rates were less than 0.5 mg $kg^{-1}d^{-1}$. White spruce may be unstable as a plantation species due to its tendency to acidify the soil. This initially promotes growth by increasing the availability of N in organic matter accumulated during previous stand growth, but eventually leads to depletion of N and other essential elements by uptake and/or leaching.

103. Hendrickson, O.Q.; Burgess, D. 1989. Nitrogen-fixing plants in a cut-over lodgepole pine stand of southern British Columbia. Can. J. For. Res. 19:936-939.

The acetylene reduction assay was used to estimate amounts of nitrogen fixed by *Lupinus arcticus* Wats. (1.97 $kg \cdot ha^{-1} \cdot year^{-1}$) and *Shepherdia canadensis* (L.) Nutt. (0.78 $kg \cdot ha^{-1} \cdot year^{-1}$) in a regenerating lodgepole pine (*Pinus contorta* Dougl.) stand in southern British Columbia. These amounts appear to be significant, as lodgepole pine ecosystems are generally highly deficient in nitrogen. Thinning of excessively dense pine stands may provide an added growth benefit by increasing nitrogen fixation activity of understory vegetation.

À l'aide de l'essai de réduction de l'acétylène, on estime les quantités d'azote fixés par *Lupinus arcticus* Wats. (1,97 $kg \cdot ha^{-1} \cdot an^{-1}$) et *Shepherdia canadensis* (L.) Nutt. (0,78 $kg \cdot ha^{-1} \cdot an^{-1}$) dans un peuplement de pins tordus (*Pinus contorta* Dougl.) en régénération dans le sud de la Colombie-Britannique. Les résultats indiquent que ces quantités semblent importantes étant donné que les écosystèmes du pin tordu sont, en général, fortement déficitaires en azote. L'éclaircie des peuplements très denses de pins pourrait

permettre d'améliorer encore plus la croissance en favorisant la fixation de l'azote par la végétation en sous-étage.

104. Hendrickson, O.Q.; Chatarpaul, L.; Burgess, D. 1989. Nutrient cycling following whole-tree and conventional harvest in northern mixed forest. Can. J. For. Res. 19:725-735.

Soil and water chemistry and soil-respiration activity were studied in a mature, mixed conifer and hardwood forest and in adjacent whole-tree harvest (WTH) and conventional harvest (CH) areas dominated by hardwood sprouts. Compared with the uncut mature forest, forest floor contents of N and K were lower in the WTH area 3 years after harvest; Ca and Mg were higher in the CH area, probably owing to inputs in logging slash. Mineral soil Ca and pH were higher in the harvested areas than in the uncut area. During the second year after harvest, cation concentrations in forest floor leachate varied in the order WTH>>CH>>uncut area, but differences largely disappeared the next year. Soil water NO_3 concentrations were slightly elevated in the CH area, but only 1.6 kg $N \bullet ha^{-1} \bullet year^{-1}$ leached below the rooting zone. Bulk precipitation K and Mg concentrations were lower in the WTH area than in the CH area owing to the loss of canopy leaching from the residual stand. Slightly higher amounts of cations were found in the snowpack under the mature forest canopy. Midwinter rains caused movement of NO_3 and H within the snowpack. Despite the higher soil-respiration rates in the harvested areas, no differences in soil organic matter pools were observed relative to the uncut area; harvest-related inputs of slash, decaying roots, and stumps may have offset respiratory carbon losses. Current high nutrient demands of rapidly growing sprouts in the WTH area greatly exceed nutrient inputs in bulk precipitation; this may lead to future growth declines.

Les caractéristiques chimiques du sol et de l'eau ainsi que l'activité respiratoire du sol sont étudiées dans une forêt mélangée mature, de conifères et de feuillus et dans des parterres de coupe adjacents, récoltés par la méthode par arbres entiers (WTH) et la méthode classique (CH), où dominaient les rejets de feuillus. Par comparaison à la forêt mature non coupée, les teneurs de la couverture morte en azote et en potassium sont plus faibles dans le parterre WTH 3 ans après la récolte, les teneurs en calcium et en magnésium sont plus élevées dans le parterre CH, en raison probablement des quantités apportées par les déchets de coupe. Le pH et les concentrations de calcium dans le sol minéral sont plus élevés dans les parterres de coupe que dans la forêt non coupée. La 2e année après la récolte, les concentrations des cations dans le lessivat de la couverture morte décroissent dans l'ordre suivant : parterre WTH>>parterre CH>>forêt non coupée; toutefois, les différences disparaissent en majeure partie l'année suivante. Les concentrations de NO_3 dans l'eau du sol sont un peu élevées dans le parterre CH, mais la quantité lessivée au-dessous de l'horizon racinaire ne représente que 1,6 kg $N \bullet ha^{-1} \bullet an^{-1}$. Les concentrations de potassium et de magnésium dans les précipitations globales sont plus faibles dans le parterre WTH que dans le parterre CH en raison de la perte de lessivage du couvert résiduel. Les cations sont légèrement plus abondants dans la neige sous le couvert de la forêt mature. Les pluies du milieu de l'hiver déplacent les ions NO_3 et H dans la couche de neige. Malgré une respiration plus élevée du sol dans les parterres de coupe, aucune différence n'est observée par rapport à la forêt mature en ce qui a trait aux réserves de matière organique; les apports par les déchets de coupe, les racines en décomposition et les souches pourraient avoir compensé les pertes de carbone par la respiration. Dans le parterre WTH, la demande d'éléments nutritifs actuellement exercée par les rejets, en croissance rapide, dépasse de beaucoup les apports par les précipitations; il pourrait s'ensuivre des réductions futures de la croissance.

105. Institut forestier national de Petawawa. 1988. Réalisations récentes à Petawawa. Mars 1988.

106. Institut forestier national de Petawawa. 1988. Réalisations récentes à Petawawa. Décembre 1988.

107. Institut forestier national de Petawawa. 1989. Réalisations récentes à Petawawa. Août 1989.

108. Institut forestier national de Petawawa. 1989. Revue des programmes 1987-1988.

109. Institut forestier national de Petawawa. 1990. Réalisations récentes à Petawawa. Avril 1990.

110. Institut forestier national de Petawawa. 1990. Revue des programmes 1988-1989.

111. Janas, P.S.; Brand, D.G. 1988. Comparative growth and development of planted and natural stands of jack pine. For. Chron. 64:320-328.

This study compares growth, yield, and stem quality differences at age 21 between plantations spaced at 2.13 x 2.13 m (2204 stems/ha) and 4.27 x 4.27 m (548 stems/ha), and a nearby natural jack pine stand of identical age (initial density of 29 800 stems/ha). Merchantable volume/ha was greatest at the 2.13 m spacing, followed by the less dense plantation and natural stand. Total volume/ha (trees >1.3 m height) was also greatest in the 2.13 m plantation, followed by the natural stand and the 4.27 m plantation. Individual tree mean merchantable volumes decreased with increasing density. Height growth decreased in both the natural stand and the 4.27 m plantation relative to the 2.13 m plantation. Stem quality of the natural stand was markedly better than in both plantations. A comparison of an older natural stand and a plantation in the same area suggests that superiority of tree form of denser natural stands will continue through to rotation. High mortality in the natural stand was largely the result of snow and ice damage which caused patchy and irregular stocking. These results imply that widely spaced plantations of unimproved jack pine will produce large individual tree sizes, but at the expense of quality.

La présente étude traite des différences de croissance, de rendement et de qualité des tiges entre les arbres de 21 ans d'une plantation espacée de 2,13 x 2,13 m (2204 tiges/ha) et d'une autre, espacée de 4,27 x 4,27 m (548 tiges/ha) et des pins gris du même âge d'un peuplement naturel avoisinant (densité initiale de 29 800 tiges/ha). Le plus fort volume marchand par hectare se retrouvait dans la plantation espacée de 2,13 m suivie de l'autre plantation et du peuplement naturel. Le plus fort volume total par hectare (arbres de plus de 1,3 m de hauteur) se retrouvait également dans la plantation espacée de 2,13 m, suivie du peuplement naturel et de la plantation espacée de 4,27 m. Le volume marchand moyen des arbres individuels décroissait avec l'augmentation de la densité. L'accroissement en hauteur diminuait dans le peuplement naturel et dans la plantation espacée de 4,27 m comparativement à la plantation à 2,13 m. La qualité de tiges du peuplement naturel était nettement supérieure à celles des deux plantations. Une comparaison d'un peuplement naturel plus âgé et d'une plantation de la même région laisse supposer que les arbres des peuplements naturels plus denses continueront d'avoir un coefficient de forme supérieur pendant toute la rotation. Les dégâts causés par la neige et la glace sont en grande partie à l'origine du taux élevé de mortalité observé dans le peuplement naturel et de la proportion irrégulière et inégale de surface occupée. Ces résultats laissent entendre que des plantations largement espacées de pins gris non améliorés produiront des arbres de haute taille, mais au détriment de la qualité.

112. Jolliffe, P.A.; Brand, D.G.; Hawkins, C.D.B. 1988. Plant growth analysis: Application to vegetation management research. Pages 72-75 *in* Hamilton, E.; Watts, S., comp. Proc. Third Ann. Vegetation Mgmt. Wkshp.: Vegetation competition and responses.

Growth analysis can provide a useful bridge between empirical and mechanistic research. A second major benefit of growth analysis is the provision of a size-independent measure of growth vigour. This feature is of particular importance in competition research where competition stress is usually inversely related to size. A third use of growth analysis is the subdivision of response into yield components.

113. Kimmins, J.P.; Scoullar, K.A.; Comeau, P.G.; Kurz, W.A.; Apps, M.J.; Chatarpaul, L. 1988. Forcyte-11: An example of the hybrid simulation approach to predicting the consequences for production, yield, economics, soil fertility, nutrient and organic matter reserves, and energy efficiency of alternative crop production systems. Pages 305-314 *in* Proc. IUFRO Conf. Forest Growth Modelling and Prediction, Vol. 1. Minneapolis, MN. Soc. Am. Foresters Publication SAF 87.12.

The eleventh version of the FORCYTE series of models is a flexible, ecosystem-level modelling framework capable of simulating most aspects of single or mixed-species even-aged forest or agroforestry crop production systems. FORCYTE-11 simulates both nutrient cycling and nutrient feedback on growth, and within-canopy light intensity profiles and the effects of shading on the production efficiency of foliage. The hybrid approach to yield prediction is explained and the model is briefly described. The application of FORCYTE-11 in tropical agroforestry is discussed as an example of the model's capabilities. Future development of FORCYTE will include an explicit treatment of moisture as a limiting factor, and improvements in the resolution of events that occur in the early years of stand establishment to make the model more useful as a vegetation management research tool.

114. Klimaszewska, K. 1989. Plantlet development from immature zygotic embryos of hybrid larch through somatic embryogenesis. Plant Sci. 63:95-103.

Embryogenic calli were initiated from immature zygotic embryos of hybrid larch dissected at the precotyledonary stage. Three media were tested, supplemented with 2 mg/L 2,4-dichlorophenoxyacetic acid and 0.5 mg/L 6-benzyladenine. The tissues were formed on all media at frequencies from 3% to 25%. The zygotic origin of calli was confirmed by chromosome counts revealing a diploid number in each of the established lines. Modified Murashige and Skoog (MS) medium was used for long term maintenance of embryogenic cultures that contained somatic embryos at early developmental stages. The growth rate and morphology of calli were influenced by the type and concentration of the gelling agent. Gelrite gellan gum was superior to Difco-Bacto agar in two of the three tested media when compared at optimal concentrations of 0.4% and 1%, respectively. Further development of somatic embryos was achieved with several treatments. The greatest number of mature embryoids was obtained on MS with 0.1 mg/L abscisic acid and 0.2 mg/L kinetin for three weeks followed by two subcultures on growth regulator-free medium. The embryoids frequently germinated on the same medium and produced plantlets. Thirty five plants have been established in soil.

115. Klimaszewska, K. 1989. Recovery of somatic embryos and plantlets from protoplast cultures of *Larix x eurolepis*. Plant Cell Rep. 8:440-444.

Somatic embryos and plantlets were regenerated from protoplasts of hybrid larch (*Larix* x *eurolepis*) isolated from two embryogenic callus and cell suspension culture lines (L1 and L2). L2, which was highly embryogenic, consistently yielded protoplasts that gave rise to somatic embryos. Centrifugation on a discontinuous medium/Percoll density gradient resulted in accumulation of embryogenic protoplasts in one of the Percoll interfaces. First division frequencies were in the range of 28-39% in line 1 and 18-20% in line 2 in both liquid and agarose-solidified culture media. The critical factor in maintaining high viability of cultures was lowering of osmotic pressure by dilution of the initial medium. The first somatic embryos were detected in 23- to 28-day-old cultures. Some of these developed into plants that were transferred to soil.

116. Klimaszewska, K.; Cheliak, W.M. 1988. Selection for glyphosate-tolerant cell cultures in poplar. Pages 17-23 *in* Ferm, A., ed. Proc. IEA Task II Meet. Cell Culture and Coppicing. Bull. Finn. Res. Inst., Kannus.

Leaf explants, callus tissue, and cell suspension of *Populus nigra* x *P. maximowiczii* were consistently induced to form shoots. The effect of glyphosate on growth and organogenesis in callus and cell suspension cultures was established. Glyphosate at 0.35 mM completely suppressed the growth and shoot formation in subcultured callus tissue. In cell suspensions, it reduced the growth rate by 70% compared to control cultures. The cell suspensions constantly growing in the presence of 0.35 and 0.7 mM glyphosate were recovered. The variant cells when cultured on agar solidified, shoot induction medium with glyphosate, maintain vigorous growth, but shoot regeneration was inhibited.

117. Klimaszewska, K.; Keller, W.A. 1988. Regeneration and characterization of somatic hybrids between *Brassica napus* and *Diplotaxis harra*. Plant Sci. 58:211-222.

Stem cortex protoplasts of *Brassica napus*, inactivated with iodoacetate, were fused with cell suspension - derived protoplasts of *Diplotaxis harra* by polyethylene glycol (PEG) treatment. PEG at 15-18% (w/v) induced 5-9% heterofusions. The hybrid callus selection was based on morphology: *D. harra* calli were yellow and very fine, while *B. napus* protoplasts typically produced green, well defined calli. A number of green, large calli were selected after fusion experiments and flowering plants were regenerated from two of these callus lines. The morphological traits as well as cytological and biochemical analysis of four isoenzymes confirmed the hybrid nature of the regenerants.

118. Kourtz, P. 1989. An expert system to predict daily forest fire occurrence. Pages 273-287 *in* Burkhart, H.E., et al., eds. Proc. IUFRO Conf. Artificial intelligence and growth models for forest management decisions. Vienna, September 18-22, 1989. School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, VA. FWS-1-89.

A PROLOG-based expert system has been created that attempts to more closely replicate an expert's approach to daily fire prediction. It integrates color graphics, geographic information, fuzzy set theory, and PROLOG-coded human knowledge related to six specific causes of forest fires (five people-caused plus lightning).

The 100 000 sq km forecast region is partitioned into a grid of about 500 equal-area cells. For people-caused fires, a mouse-driven color graphic scheme permits an expert to rapidly 'paint' on a map of the region his or her geographic perceptions of the location and seriousness of the fire risk associated with each general cause, assuming worst-case risk conditions. For each cell, about 1000 expert rules are used to modify these potential risks to actual risks of the forecast period. Lightning risk is established by combining regional real-time lightning sensor flash locations, forest cover and weather data, existing process models, and expert rules. Another 1000 rules are used to estimate the cell's fire hazard or detectability state. Fuzzy set concepts are used to combine each cell's risks and hazard into a fuzzy danger representing the degree of belief that a fire should be detected in the cell during the forecast period. Output is in the form of coloured maps showing fuzzy classes of risk, hazard, and danger.

The system was field tested at two fire centers during the summers of 1988 and 1989. Although it is still too early in the testing and modification process to make general conclusions, early indications are that this system represents a significant advance in fire occurrence prediction.

The method for entering and processing geographic perceptions should have many other applications as a means to combine subjective expert opinions with geographic information.

119. Kourtz, P. 1989. Two dynamic programming algorithms for forest fire resource dispatching. Can. J. For. Res. 19:106-112.

The dispatch of water bombers and fire-fighting crews to newly reported fires is an important task carried out by modern regional forest fire management centres. The problem of bomber dispatch involves the use of aircraft of varying speeds, cost, and fire-fighting effectiveness. Candidate aircraft for dispatch can be situated at remote attack bases or at ongoing fires. The problem of crew dispatch also involves candidate crews situated at remote attack bases or at ongoing fires, but unlike bomber dispatch, helicopter transport must be arranged. A transport helicopter must be flown to the specific crew's location and then to the fire. A helicopter is permitted a second trip to pick up an additional crew. The bomber- and crew-dispatch problems have both been formulated as dynamic programming algorithms. The bomber formulation closely resembles the traditional "knapsack" formulation. The crew and helicopter dispatch problem involves a more general formulation. Both algorithms are illustrated by simple examples. FORTRAN programs have been written for both algorithms. These programs are embedded within a large expert system which defines the desired bomber force and number of crews to be dispatched to a specific fire. This system is presently being tested at the North Central Regional Fire Centre of the Ontario Ministry of Natural Resources, located at Thunder Bay. It is expected that this system will undergo several years of testing and modifications before it is considered operational. Recent trials at the Thunder Bay fire centre have demonstrated the potential of the expert system, including the two dynamic programming algorithms, by matching or exceeding the dispatching performance of the dispatchers.

L'envoi d'avions-citernes et d'équipes d'extinction sur les lieux d'incendies nouvellement déclarés est l'une des fonctions importantes des centres régionaux modernes de lutte contre les incendies de forêt. Les avions-citernes varient sur les plans de la vitesse, du coût et de l'efficacité pour la lutte contre les incendies, et ils peuvent aussi se trouver à des bases d'attaque éloignées ou sur les lieux d'un autre incendie en cours. Dans le cas des équipes d'extinction, celles-ci peuvent également se trouver à des bases d'attaque éloignées ou sur les lieux d'un autre incendie, mais on doit également prendre en considération dans leur cas le transport par hélicoptère; l'hélicoptère doit aller chercher l'équipe là où elle se trouve et la conduire au feu, et il peut également avoir à transporter une deuxième équipe. Les deux problèmes d'envoi d'avions-citernes et d'équipes d'extinction ont été formulés sous forme d'algorithmes de programmation dynamique. La formulation pour l'envoi d'avions-citernes ressemble beaucoup à la formulation traditionnelle à empilement («knapsack»). Le problème d'envoi des équipes par hélicoptère a une formulation plus générale. Les deux algorithmes sont illustrés au moyen d'exemples simples. Ils ont été écrits sous forme de programmes en FORTRAN. Ces programmes font partie d'un important système expert qui détermine le nombre d'avions requis pour l'arrosage et le nombre d'équipes à envoyer pour un incendie donné. Le système est actuellement à l'essai au centre de lutte contre les incendies de la région du centre-nord du ministère des Richesses naturelles de l'Ontario, à Thunder Bay. On estime qu'il devra faire l'objet d'essais et de modifications pendant plusieurs années avant de pouvoir être considéré comme opérationnel. Les essais effectués récemment à Thunder Bay ont démontré son potentiel, y compris les deux algorithmes de programmation dynamique; il a réussi à égaler et même à dépasser la performance des coordonnateurs.

120. Kourtz, P. 1990. Artificial intelligence: new tool for forest management. Can. J. For. Res. 20:428-437.

Artificial intelligence is a new science that deals with the representation, automatic acquisition, and use of knowledge. Artificial intelligence programs attempt to emulate human thought processes such as deduction, inference, language, and visual recognition. The goal of artificial intelligence is to make computers more useful for reasoning, planning, acting, and communicating with humans. Development of artificial intelligence applications involves the integration of advanced computer science, psychology, and sometimes robotics. Of the subfields that artificial intelligence can be broken into, the one of most

immediate interest to forest management, is expert systems. Expert systems involve encoding knowledge usually derived from an expert in a narrow subject area and using this knowledge to mimic his decision making. The knowledge is represented usually in the form of facts and rules, involving symbols such as English words. At the core of these systems is a mechanism that automatically searches for and pieces together the facts and rules necessary to solve a specific problem. Small expert systems can be developed on common microcomputers using existing low-cost commercial expert shells. Shells are general expert systems empty of knowledge. The user merely defines the solution structure and adds the desired knowledge. Larger systems usually require integration with existing forestry data bases and models. Their development requires either the relatively expensive expert system development tool kits or the use of one of the artificial intelligence development languages such as LISP or PROLOG. Large systems are expensive to develop, require a high degree of skill in knowledge engineering and computer science, and can require years of testing and modification before they become operational. Expert systems should have a major role in all aspects of Canadian forestry. They can be used in conjunction with conventional process models to add currently lacking expert knowledge or as pure knowledge-based systems to solve problems never before tackled. They can preserve and accumulate forestry knowledge by encoding it. Expert systems allow us to package our forestry knowledge into a transportable and saleable product. They are a means to ensure consistent application of policies and operational procedures. There is a sense of urgency associated with the integration of artificial intelligence tools into Canadian forestry. Canada must awaken to the potential of this technology because such systems are essential to improve industrial efficiency. A possible spin-off will be a resource knowledge business that can market our forestry knowledge worldwide. If we act decisively, we can easily compete with other countries such as Japan to fill this niche. A consortium of resource companies, provincial resource agencies, universities, and federal government laboratories is required to advance this goal.

L'intelligence artificielle est une nouvelle science qui traite de la présentation, de l'acquisition automatique et de l'utilisation des connaissances. Les programmes d'intelligence artificielle tentent d'émuler les processus intellectuels humains comme la déduction, l'interpolation, le langage et la reconnaissance visuelle. Le but de l'intelligence artificielle est de rendre les ordinateurs plus efficaces dans les travaux de raisonnement, de planification, des applications et de la communication avec l'être humain. La création d'applications pour l'intelligence artificielle passe par l'intégration de formes avancées d'informatique, de psychologie et parfois de robotique. L'intelligence artificielle peut être décomposée en sous-domaines, dont les systèmes experts constituent celui qui offre le plus d'intérêt immédiat en termes de gestion forestière. Les systèmes experts doivent faire le codage des connaissances habituellement fournies par un expert dans un domaine d'expertise spécialisé et l'utilisation de ces connaissances pour mimer le processus de prise de décision chez ces experts. Les connaissances sont le plus souvent organisées sous forme d'affirmations et de règlements à l'aide de symboles comme des mots anglais. Au cœur de ces systèmes, on trouve un mécanisme de recherche et de regroupement automatiques des affirmations et des règles nécessaires à la résolution de problèmes particuliers. Il est possible de créer de petits systèmes experts sur des micro-ordinateurs courants au moyen de systèmes experts génériques d'un prix abordable. Ces systèmes génériques sont des systèmes experts généraux qui ne contiennent aucune connaissance. L'utilisateur se contente de définir la structure de solution et ajoute les connaissances requises. Les gros systèmes nécessitent généralement l'intégration avec les modèles et les bases de données existantes de foresterie. Pour leur mise au point, il faut des trousses assez coûteuses d'élaboration du système expert sinon il faut passer par un des langages spécialisés comme le LISP ou le PROLOG. L'élaboration des systèmes de grande capacité est coûteuse, et il faut être très spécialisé en génie cognitif et en informatique; en outre, il peut falloir des années d'essais et de dévelopement avant de rendre le système opérationnel. Les systèmes experts devront avoir une place importante dans tous les aspects de la foresterie au Canada. Ils peuvent être utilisés en conjonction avec des modèles classiques et apportent les connaissances spécialisées qui manquent, ou encore ils peuvent être utilisés comme tels pour résoudre des problèmes nouveaux. Ils peuvent servir à conserver et à accumuler nos connaissances en foresterie en les encodant. Les systèmes experts nous permettent de présenter nos connaissances en foresterie sous la forme d'un produit livrable et commecialisable. Ils constituent un moyen d'assurer

l'application consistante de politiques et de procédé opérationnels. L'intégration des outils d'intelligence artificielle dans le domaine de la foresterie au Canada devient urgente. Le Canada doit prendre conscience du potentiel de cette technologie car de tels systèmes sont essentiels à l'amélioration de l'efficacité industrielle. Une des retombées possibles sera la création d'une industrie des connaissances de nos ressources qui nous permettra de commercialiser dans le monde notre connaissance de la foresterie. En nous engageant résolument dans cette voie, nous pourrons facilement concurrencer d'autres pays comme le Japon et occuper ainsi cette niche. Pour parvenir à cet objectif, il est nécessaire de constituer un consortium d'entreprises, d'organismes provinciaux, d'universités et de laboratoires du gouvernement fédéral qui s'occupent de ces ressources.

121. Larocque, G.; Marshall, P.L. 1988. Growth and yield of spruce in the inland mountain west: a literature review. Pages 192-196 *in* Schmidt, W.C., comp. USDA Forest Serv. Gen. Tech. Rep. INT-243.

This paper contains a compilation of the literature available on the growth and yield of the spruce species found in the Inland Mountain West of the United States and Canada. With the exception of Engelmann spruce (*Picea engelmannii* Parry), little information was found on the growth of natural stands of these species within this region. Almost no information was located on the effect of density on the development of managed stands. The necessity of maintaining existing spacing studies and implementing new trials is noted.

122. Larocque, G.; Marshall, P.L. 1988. Improving single-tree distance-dependent growth models. Pages 94-101 *in* Ek, A.R. et al., eds. Proc. IUFRO Conf., Minneapolis, MN. USDA Forest Serv. Gen. Tech. Rep. NC-120.

Single tree distance dependent growth models can be improved in several ways. The greatest potential for improvement is in the way competition is modelled. New techniques based on a holistic approach to the competitive process are required. The development of such techniques depends on acquiring detailed data on the underlying processes. Detailed long-term data can also help reduce the variation which remains unexplained by the model. Less reliance on multiple linear regression techniques, and shortening the prediction periods should also improve the accuracy of single-tree distance-dependent models.

123. Leckie, D.G. 1990. Advances in remote sensing technologies for forest surveys and management. Can. J. For. Res. 20:464-483.

Canadian forest management has had a long history of developing and implementing remote sensing technology and is a major user of remote sensing data. Despite difficulties in developing and implementing new digital remote sensing techniques, several key developments in Canadian forest management and in remote sensing and computer technology make the development and implementation of new remote sensing techniques at this time feasible and appropriate. Integration of different remote sensing technologies, remote sensing data with other information sources through geographic information systems, and remote sensing interpretations with forest management systems and practices are critical. Current capabilities and new advances in remote sensing technology for forest survey (excluding forest damage assessment) are discussed. Satellite imagery is a cost-effective tool for broad forest type mapping. New satellite systems improve this capability, but their major impact will be in inventories for new clear-cut and burned areas. Advances in linear array imager technology and lidar systems may lead to development of an end to end inventory mapping system. This system would provide an alternative to aerial photography and current mapping methods and could revolutionize the way forests are inventoried. Imaging spectrometry is a new technology with applications in damage assessment, but as yet has limited potential for assisting in other forest surveys. Spaceborne imaging radar systems are being developed for the 1990s. These systems can produce imagery under

cloudy conditions. Their major impact on forestry will be to provide an alternative to visible-infrared satellite data for inventory update.

Depuis nombre d'années, le secteur de l'aménagement forestier du Canada développe et met en application des techniques de télédétection. Il est aussi l'un des principaux utilisateurs de la télédétection. La mise au point et l'application de nouvelles techniques digitales de télédétection, même si elles comportent certaines difficultés, sont maintenant possibles et de circonstance, grâce à plusieurs développements clés dans le secteur canadien de l'aménagement forestier ainsi que dans les domaines de la télédétection et de l'informatique. L'intégration de différentes technologies de télédétection, des données de télédétection avec celles provenant d'autres sources d'information grâce aux systèmes d'information géographique et des interprétations de ces données aux systèmes et aux pratiques d'aménagement forestier sont extrêmement importantes. Les possibilités actuelles et les nouveaux progrès techniques réalisés en télédétection pour les relevés forestiers (à l'exclusion de l'évaluation des dommages causés aux forêts) sont discutés. L'imagerie satellite est un moyen rentable de faire la cartographie générale des forêts. Les nouveaux systèmes satellites constituent une amélioration à cet égard, mais ils seront surtout utiles pour l'inventaire des nouvelles surfaces de coupes rases ou brûlées. Les progrès techniques réalisés avec les systèmes imageurs à réseaux linéaires et lidar peuvent mener à la création d'un système de cartographie complète pour les inventaires. Ce système pourrait fournir une alternative à la photographie aérienne et aux méthodes actuelles de cartographie ainsi que révolutionner la façon de faire dresser les inventaires forestiers. La spectrométrie d'imagerie est une nouvelle technologie ayant des applications pour l'évaluation des dommages, mais, pour aider à effectuer d'autres relevés forestiers, ses possibilités sont encore limitées. Les systèmes imageurs radar satellites sont en voie de développement pour les années 1990. Ces systèmes permettent de produire des images même si le temps est nuageux. Leur impact majeur sur la foresterie sera en tant qu'une nouvelle possibilité vis-à-vis de satellites opérants dans la région du visible à l'infrarouge pour la mise à jour des inventaires.

124. Leckie, D.G. 1990. Innovation in remote sensing. Pages 108-112 *in* Proc. 13th Commonw. For. Conf. Forest Res. Inst., Rotorua, N.Z.

As pressures on the forest resource increase and multiple-use forestry becomes more common, forest management becomes more complex and the demand for accurate, detailed, and up-to-date information increases. As the technological infrastructure in the forestry community becomes more sophisticated, the ability of forest managers to make complex decisions and use a variety of data types from diverse sources expands. There is, therefore, a demand for innovation in remote sensing, both in development of new technologies and more appropriate application of existing methods. Key areas of innovation in remote sensing are highlighted.

125. Leckie, D.G. 1990. Synergism of synthetic aperture radar and visible/infrared data for forest type discrimination. Photogramm. Eng. Rem. Sens. 56:1237-1246.

Five visible, three near-infrared, and one mid-infrared airborne MSS bands and eight airborne synthetic aperture radar (SAR) bands were acquired during summer over a forest test site near Chalk River, Ontario, Canada. The radar bands were X (3.2 cm) and C (5.6 cm) recorded with both vertical and horizontal transmit and receive polarization (i.e., X_{VV}, X_{VH}, X_{HH}, X_{HV}, C_{VV}, C_{VH}, C_{HH}, C_{HV}). Radiometric corrections were applied and the data were geometrically registered at a 10-m resolution.

Radar bands were better at discriminating softwood species than were the visible/infrared bands. Red and white pine had relatively low microwave backscattering, whereas jack pine and white spruce had high backscattering. The hardwoods tested had intermediate to high backscattering. Use of a near-infrared or mid-infrared band is important for distinguishing hardwoods from softwoods. Visible and mid-infrared bands are useful for discriminating open areas with either sparse, moderate, or dense ground vegetation from forested areas. No specific band was consistently better than others for

differentiating young and mature stands of several different species. Maximum average classification accuracy for seven forest types was 74 percent. The best five bands in combination with each other for discriminating general forest stand types were a near-infrared band, a green band, a mid-infrared band, X_{VV}, and C_{HH}. Classification accuracy using these five bands was 67 percent. Synergism of visible/infrared and radar data results in improved forest mapping capabilities.

126. Leckie, D.G.; Ostaff, D.P. 1988. Classification of airborne multispectral scanner data for mapping current defoliation caused by the spruce budworm. For. Sci. 34:259-275.

Airborne multispectral scanner data were acquired over a mixed fir and spruce forest affected by both current defoliation (red discoloration) and cumulative defoliation (loss of needles) caused by feeding of the spruce budwrom (*Choristoneura fumiferana* [Clem.]). The spectral bands, ratios and differences of bands, and principal components derived from the bands were examined for their usefulness for discriminating defoliation condition. Classifications were conducted using the best combinations of two through nine bands or features derived from the bands. Three levels of current defoliation could be classified (heavy, light, and healthy). Cumulative defoliation and mixed-wood areas caused confusions in the classifications. There was little advantage to including more than four bands or derived features in the classifications.

127. Leckie, D.G.; Ostaff, D.P.; Teillet, P.M.; Fedosejevs, G. 1989. Spectral characteristics of tree components of balsam fir and spruce damaged by spruce budworm. For. Sci. 35:582-600.

Spectral reflectances from 360 to 1100 nm at 5 nm intervals in 6 nm bands were measured with a laboratory spectrometer for samples of the components of balsam fir and white spruce trees defoliated by the spruce budworm. These components included current-year needles, 1-year-old needles, 2-year and older needles, budworm feeding debris, twigs, bark, and lichen. Current-year needles had significantly higher reflectances than older needles in the green and yellow parts of the spectrum. Feeding debris, which is visually red, had a smooth spectral curve of increasing reflectance with wavelength. The greatest difference between needles and feeding debris was in the short near-infrared wavelengths and at the chlorophyll absorption maximum near 670 nm. The reflectance of twigs and bark changed with age and exposure to weathering. Variability in their reflectance was large. There were no distinct narrow band features of twig or feeding debris reflectance, which would be characteristic of defoliation. Lichen is highly reflective, and its presence on branches of defoliated trees will greatly alter branch reflectance characteristics. Changes in spectral reflectance of trees throughout the various stages of a spruce budworm outbreak depend on a complex interrelationship of the reflectances of individual components which, in turn, are complex and changing.

128. Leckie, D.G.; Teillet, P.M.; Fedosejevs, G.; Ostaff, D.P. 1988. Reflectance characteristics of cumulative defoliation of balsam fir. Can. J. For. Res. 18:1008-1016.

Knowledge of the spectral characteristics of trees with varying degrees of needle loss is essential for developing remote sensing techniques for assessing defoliation. Spectra covering the range 400-2400 nm were acquired for single tree crowns suffering varying degrees of cumulative defoliation due to the spruce budworm (*Choristoneura fumiferana* [Clem.]), using a spectrometer mounted in the bucket of a boom truck. Spectra over the range 360-1100 nm were also obtained for the components of defoliated trees (i.e., needles, bare branches, and lichen), using a separate spectrometer and integrating sphere. Estimates of defoliation symptoms of each tree were made from the ground and above the tree. Changes in reflectance had a close and simple relationship with the defoliation symptoms measured. The spectral differences due to cumulative defoliation that were observed were broad-band features. The best spectral regions for differentiating levels of cumulative defoliation symptoms were the blue, red, shorter near-infrared wavelengths, and middle-infrared. Although currently available satellite and airborne sensors operate in these spectral regions, defoliation assessment may be improved by the use of optimized spectral bands.

Une connaissance des caractéristiques spectrales des arbres dont la perte des aiguilles est d'intensité variable est essentielle à la mise au point de techniques de télédétection servant à évaluer la défoliation. En utilisant une spectromètre monté dans la benne d'un camion à bras extensible, des spectres couvrant un étendue de 400 à 2400 nm ont été obtenus pour les cimes d'arbres qui accusaient à divers degrés une défoliation cumulative due à la tordeuse des bourgeons de l'épinette (*Choristoneura fumiferana* [Clem.]). On a aussi obtenu des spectres d'une étendue de 360 à 1000 nm pour les différentes parties des arbres défoliés (c'est-à-dire les aiguilles, les branches nues et le lichen), à l'aide d'un autre spectromètre et d'une sphère d'intégration. Une estimation des symptômes de défoliation de chaque arbre a été faite à partir du sol et du dessus des arbres. Les changements de réflectance étaient en relation étroite et simple avec les symptômes de défoliation mesurés. Les différences spectrales observées, dues à la défoliation cumulative, étaient des caractéristiques du type «bande large». Les régions idéales du spectre pour différencier les niveaux de symptômes de la défoliation cumulative se situaient dans le bleu, le rouge, les longueurs d'ondes courtes de l'infrarouge proche et de l'infrarouge moyen. Quoique les satellites actuels et les détecteurs aéroportés présentement sur le marché peuvent fonctionner dans ces régions spectrales, l'évaluation de la défoliation pourrait être améliorée si l'on se servait de bandes spectrales optimisées.

129. Leckie, D.G.; Teillet, P.M.; Ostaff, D.P.; Fedosejevs, G. 1988. Sensor band selection for detecting current defoliation caused by the spruce budworm. Rem. Sens. Environ. 26:31-50.

Ground-based spectral data were obtained for single crowns of balsam fir trees with varying degrees of current defoliation caused by feeding of the spruce budworm (*Choristoneura fumiferana* [Clem.]). These data were acquired with a Spectrascan spectrometer mounted on a 21-m boom truck, which provided spectral reflectances in 117 wavelength bands from 380 to 2400 nm. The spectra were related to measures of defoliation symptoms: needle loss, quantity of red needles and other feeding debris, and exposure of bare twigs. Wavelength bands suitable for discriminating different levels of these damage symptoms were defined and compared with wavelength bands available with various airborne and satellite sensors. The most effective bands, in order of importance, were 2030-2210, 660-670, 1560-1620, and 770-790 nm. Well-placed, narrow wavelength bands are important for discriminating levels of current defoliation caused by spruce budworm feeding.

130. Magnussen, S. 1988. Minimum age-to-age correlations in early selections. For. Sci. 34:928-938.

The concepts and computational procedures of minimum age-to-age selection efficiency and correlations are introduced to assist the tree breeder in deciding selection age. When observed age-to-age correlation in a field test exceed the required minimum, selection at the current age will yield a higher rate of improvement than selection at an older age.

131. Magnussen, S. 1989. Age-to-age correlations in growth processes with fixed and random effects. Silvae Genet. 38:49-55.

The author develops a model to predict phenotypic single tree age-to-age correlations. Correlations are predicted from variance ratios and a factor d which depicts the relative proportion of size dependent growth in a quantitative juvenile trait. Observed age 10 to age 35 correlations of stem volume in a *Pinus resinosa* (Ait.) spacing trial indicated that the model is a good first approximation at a spacing of 2 m x 2 m. Correlations were underestimated at closer spacings and overestimated at wider spacings. Prediction bias could be explained by spacing dependent changes in d. With time, d approached an upper limit asymptotically. Accurate predictions were possible once d was close to its limit. Examples from the literature illustrated the potential for predicting age-to-age correlations of tree height. An applicaton of the model as a tool for tree breeders to settle questions about selection age is demonstrated.

132. Magnussen, S. 1989. Determination of optimum selection ages: a simulation approach. Pages 259-285 *in* Proc. 20th South. Tree Improv. Conf. June 26-30, 1989, Charleston, SC.

Prediction models of growth (height and stem volume), phenotypic variation, heritability, and age-to-age correlations provided an integrated framework for predicting optimum selection ages in a breeding program of fixed duration. The risks of early selection were assessed by computing a minimum significant gain ratio of juvenile selection; only gain ratios exceeding this minimum were permissible options for juvenile selections. Optimum selection ages were either very low (usually below one-sixth of the rotation age) or equal to the rotation age itself. Although intermediate selection ages promised more gain per unit time than selection at rotation age, the gain did not outweigh the associated risk. Slow growth (high rotation) made juvenile selection more attractive than it was in the fast growth scenarios. Minor changes in model parameters often had dramatic impacts on the age of optimum gain ratio. The simulation approach to estimation of optimum selection ages provides an useful tool for sensitivity analyses of a gain expression with many interrelated parameters.

133. Magnussen, S. 1989. Effects and adjustments of competition bias in progeny trials with single-tree plots. For. Sci. 35:532-547.

A competition model based on the height difference between a subject tree and its neighbors was used to adjust annual growth data (age 1-5) in a close-spaced single tree plot trial of 25 open-pollinated *Pinus banksiana* progenies. Competition effects on tree height, basal area, and volume growth were estimated within each of eight classes of dominant suppression. This procedure allowed a differential adjustment of family performances to their large plot expectations. It is limited to the absence of competition effects on height growth. Response to competition was the same in all families. Variance components and heritability estimates of basal area and stem volume were inordinately inflated by competition.

134. Magnussen, S. 1989. Inter-plant interactions and their influence on within and among-plot variances. Scand. J. For. Res. 4:369-377.

Analytical and empirical relationships are established among parameters of spatial interactions among plants (Mead's coefficient of inter-plant interaction (competition), Smith's empirical law of soil heterogeneity, intra-plot correlations, and spatial autocorrelation). The significance of spatial inter-plant interactions on the statistical efficiency of field design, sample sizes, and field estimates is discussed by the author. Besides providing insight into the complexities of inter-plant interactions, the exposition also provides procedures for removing the bias generated by these interactions and algorithms for obtaining spatial parameters from ANOVA results.

135. Magnussen, S. 1990. Alternative analyses of parent-offspring correlations for stem straightness in jack pine. Silvae Genet. 39:237-244.

Parental phenotypes of stem form in jack pine (*Pinus banksiana* Lamb.) explained a highly significant proportion (0.11, $P = 0.01$) of the variability in stem straightness among their offspring. Overall, the narrow-sense heritability of stem straightness scores was comparatively high (about 0.3) in progenies from 43 assortative matings (mainly positive) of parents with contrasting phenotypic scores. Three statistical procedures (parent-offspring regression, maximum likelihood, and tetrachoric correlations) for calculating parent-offspring correlations in the presence of nonrandom mating, unequal family sizes, and a limited range of straightness scores are compared and discussed. Problems related to using parent-offspring regression for traits with only a few subjective scoring categories dissuade its use. As an alternative, estimating tetrachoric correlations is recommended owing to the computational ease and less restrictive assumptions associated with the procedure.

136. Magnussen, S. 1990. Application and comparison of spatial models in analyzing tree-genetics field trials. Can. J. For. Res. 20:536-546.

Tree height of jack pine full-sib families, originating from all possible combinations of three parental provenances and growing on three sites, was analyzed with 1 classical model and 11 nearest-neighbour spatial process models. Extension of the classical linear model with spatial interaction terms was deemed necessary in light of significant neighbourhood correlations among effect-free observations (residuals) on two of the three sites. The strength and extent of spatial and temporal correlations are demonstrated in both visual and tabular form. Only 4 of the 11 spatial models provided a substantial reduction (5-20%) in the significant difference between two estimates of full-sib family tree height. Spatial adjustments averaged 1-3% at the family level, with few families adjusted by more than 10%. The cumulative (temporal) effect of spatial covariance was demonstrated in rank correlations between adjusted and observed family means. No simple trends were obtained when adjusted variance components and heritabilities were compared with their unadjusted counterparts, but most models tended to deflate genetic effects and reduce heritabilities. It is concluded that although spatial analyses provide an attractive tool for the experimenter, the lack of a cause and effect hypothesis in forest genetic trials necessitates model searching without the guarantee of true treatment effects. Spatial analysis provides good indicators of the need to collect additional site information for more powerful analyses. Careful planing and intensive site preparation may greatly reduce spatial covariances and the need for spatial analyses.

La hauteur des familles bi-parentales de Pin gris originant de toutes les combinaisons possibles de trois provenances parentales et croissant sur trois sites ont été analysées avec 1 modèle classique et 11 modèles spatiaux de plus proche voisin. L'extension du modèle classique linéaire avec les termes de l'interaction spatiale a été jugée nécessaire à la lumière de corrélations significatives de voisinage entre les observations sans effets sur deux des trois sites. La force et l'étendue des corrélations spatiales et temporalles sont démontrées sous forme visuelle et en tableaux. Seulement 4 des 11 modèles spatiaux conduisaient à une réduction substantielle (5-20%) de la différence significative entre deux estimations des familles de hauteur. Les ajustements spatiaux exprimaient en moyenne 1-3% du niveau de la famille avec quelques familles ajustées par plus de 10%. L'effet cumulatif temporel de la covariance spatiale a été démontrée dans les corrélations de rang entre les moyennes de famille ajustées et observées. Aucune tendance linéaire n'a été obtenue lorsque les composantes ajustées de la variance et les facteurs héréditaires ont été comparés avec leurs contreparties non ajustées mais la plupart des modèles tendent à diminuer les effets génétiques et réduire les facteurs héréditaires. Nous concluons que même si les analyses spatiales procurent un outil attrayant pour le chercheur, le manque de cause et d'effets hypothétiques dans les essais en génétique forestière nécessitent des modèles de recherche sans garantie de vrais effets de traitements. L'analyse spatiale fournit de bons indicateurs de la nécessité d'obtenir de l'information additionnelle sur les sites pour une analyse plus puissante. La préparation intensive de sites et une planification soignée peuvent réduire de beaucoup les covariances spatiales et le besoin d'analyses spatiales.

137. Magnussen, S. 1990. Selection index: economic weights for maximum simultaneous genetic gain. Theor. Appl. Genet. 79:289-293.

Selection indices that maximize the correlation between an individual organism's index score and its breeding value frequently require *a priori* "economic" weights before the optimum phenotypic weights can be estimated. The long generation intervals and economic uncertainty that surround forest tree breeding can make the choice of weights arbitrary. In this paper an algorithm is introduced for finding "economic" weights that will ensure maximum simultaneous progress in all index traits. At the outset the traits are assumed to be of equal preference. The solutions are functions of the eigen values and eigenvectors of a quadratic form of the additive genetic and phenotypic covariance matrices. Examples of applications in tree breeding emphasize the practical aspects of the method.

138. Magnussen, S. 1990. Stochastic dynamics of age-to-age correlations. Paper 4.86 *in* Proc. Joint Meeting Western Forest Genet. Assn. and IUFRO Wk. Parties S2.02-05, 06, 12, 14. Olympia, WA, Aug. 20-24, 1990.

Age-to-age correlations can be considered as repeatabilities of tree performance during the period in question. Stated as a repeatability the stochastic dynamic and probability distributions of age-to-age correlations are apparent and provides a logical link between different types of correlations (phenotypic, genotypic, and environmental). A Fourier transformation of time series of standardized trait values allowed an orthogonal decomposition of the total variance into the desired among- and within-tree variance. A validation exercise supported the model derivations.

Les correlations âge-âge peuvent être considérées comme répétabilités de la performance des arbres pendant la période visée. Affirmée comme répétabilité, la dynamique stochastique et la distribution des probabilités des correlations âge-âge sont évidentes en assurant un lien logique entre les correlations des types différents (phénotypique, génotypique et environnemental). La transformation Fourier des séries de temps, concernant les caractères normalisés des valeurs, permettent d'établir une répartition orthogonale de la variance totale en caractères individuels ou correlationnels des arbres. Un exercice de validation soutient le modèle.

139. Magnussen, S.; Brand, D.G. 1989. A competition process driven growth model for red pine. PI-X-89.

A simulation model, predicting individual tree growth and mortality, is developed using data from a red pine spacing trial. Changes in relative growth rates as related to changes in tree size, the size of the individual tree relative to the median population size, and the overall stand density are central elements of the model. The model parameters are biologically interpretable as measures of the process of competition. Data from six spacings were used to develop the model whereas a different data set from eight spacings served to validate the model. Inclusion of random but correlated error components provided the basis for stochastic simulations. Based on individual stem volume and stand area at age 10 as input, the model was used to predict trends in tree volume distributions until age 35. A detailed graphical representation of model output (summary statistics of stem volume distributions) is presented and compared with observed data. Prediction errors of most results were as a rule below 25%; smaller errors were associated with shorter prediction periods. It is concluded that the model realistically generates the temporal dynamics of volume distributions in even-aged red pine plantations. Failure to predict stand development beyond a square spacing of 3.0 m, and poor predictions for the 1.2 m, spacing limits model application to initial spacings between 1.5 m and 3.0 m. The limited requirement for input data makes the model an attractive tool for growth and yield simulation.

140. Magnussen, S.; Brand, D.G. 1990. Modèle de croissance du pin rouge, fondé sur le processus de compétition. PI-X-89F.

Un modèle de simulation de la croissance et de la mortalité des individus a été construit à l'aide des expériences sur l'espacement des plantations de pins rouges. Les changements des taux de croissance relatifs se rapportant à la taille des arbres, à la taille des individus par rapport à la taille moyenne de la population et à la densité du peuplement en général sont les principaux éléments du modèle. Du point de vue biologique, les paramètres du modèle permettent de mesurer le processus de compétition. Les données provenant de six essais d'espacement ont servi à créer le modèle qui a été validé par les résultats des huit autres essais d'espacement. Les simulations stochastiques s'appuient sur l'inclusion des erreurs aléatoires, mais corrélatives. D'après le volume individuel des tiges et la superficie d'un peuplement âgé de 10 ans, le modèle permet de prévoir la tendance dans la distribution du cubage des arbres jusqu'à l'âge de 35 ans. Les résultats obtenus à l'aide du modèle (résumé statistique de la distribution du cubage) sont présentés au moyen d'un graphique détaillé et ils sont comparés aux données

d'observations. En général, la marge d'erreur des prévisions était inférieure à 25 % et elle était plus faible pour des périodes de prévision plus courtes. Les auteurs arrivent à la conclusion que le modèle reproduit de façon réaliste la dynamique temporelle de la distribution du cubage dans une plantation équienne de pins rouges. En raison de l'échec des prévisions de la croissance d'un peuplement pour un espacement en quinconce de plus de 3 m et du manque de précision pour un espacement de 1,2 m, l'application du modèle est restreinte à des espacements initiaux variant entre 1,5 et 3 m. Puisqu'un petit nombre de données d'entrée suffit à créer le modèle, celui-ci se révèle un outil intéressant pour simuler la croissance et la possibilité.

141. Magnussen, S.; Keith, C.T. 1990. Genetic improvement of volume and wood properties of jack pine: selection strategies. For. Chron. 66:281-286.

Six selection strategies aimed at genetically improving volume production and wood quality factors such as density, heartwood content, and stem taper are compared in a 20-year-old jack pine progeny trial. Selection indices were computed under various assumptions about economic values of the traits under selection and with contraints on the magnitude and direction of expected genetic gain. Stem taper, wood density, and heartwood content were under strong genetic control; however, the low phenotypic variation of wood density limits its potential for genetic improvement. Heartwood content emerged as a trait amenable for rapid genetic improvement. Despite low heritabilities, the prospect of improving size-related traits was promising due to substantial phenotypic variation. Economic weights were important for the selection outcome and good progress was reported in all traits when volume received the highest weight. It was feasible to limit genetic gain in individual traits to predetermined relative levels but the cost in terms of reduced gain in unrestricted traits was economically debilitating. Concerns about undesirable concomitant changes in wood density, heartwood, and stem taper when breeding is based solely on growth traits were not confirmed by our data.

Six stratégies de sélection ont été élaborés en vue d'améliorer génétiquement le rendement en volume ainsi que les caractéristiques de qualité de bois, comme la densité, le contenu du durament et le défilement de la tige. Ces caractères sont comparés lors d'un test de descendance de pin gris de 20 ans. Les indices de sélection sont évalués selon diverses hypothèses quant aux valeurs économiques des caractéristiques de sélection et sous diverses contraintes de l'ampleur et la direction du gain génétique prévu. Le contrôle génétique comprend le défilement de la tige, la densité de bois et le duramen. Puisque la densité de bois montre peu de variation phénotypique, son potentiel d'amélioration génétique est limité. Le contenu du duramen s'avère un caractère qui peut être le plus facilement et le plus rapidement amélioré du point de vue génétique. Bien que les caractères physiques reliés aux dimensions représentent une faible héritabilité, leur amélioration s'annonce bien, grâce à de fortes variations phénotypiques. L'aspect économique, tenant compte des résultats de la sélection, est important. Tous les caractères se développent bien lorsque le volume est considéré comme le plus essentiel. Il est possible de déterminer le gain génétique des caractères individuels à des niveaux relatifs préétablis, toutefois, les frais paraissent élevés, vu le gain réduit quant aux caractères non restreints. Selon nos données, il n'y a pas de changements concomitants non désirables en ce qui concerne la densité de bois, le duramen et le défilement de la tige dans le cas du croisement fondé uniquement sur les caractères de croissance.

142. Magnussen, S.; Yeatman, C.W. 1988. Height growth and survival of within- and between-provenance crosses in jack pine. Can. J. For. Res. 18:1145-1151.

Controlled pollinations with provenances from Petawawa (Ontario), Fife Lake (Michigan), and Big River (Saskatchewan) were made in all possible combinations, with the ensuing offspring planted at three sites along a north-south transect in Ontario. Survival at age 8 decreased with increased boreal character at the site. Survival of provenance hybrids was intermediate to that of their intraprovenance counterparts. Statistically significant heterosis (departure from midvalue of associated intraprovenance performances) was observed in tree height at two locations. At the northernmost site, growth was poor, with no significant differentiation among any of the tested full-sib

families. Within-block microsite quality was unevenly distributed at two sites, which resulted in a low blocking efficiency and a highly significant among-plot variation. However, with five full-sib families per provenance cross, the impact on the statistical analysis of crosses was negligible.

Des pollinisations croisées suivant toutes les combinaisons possibles ont été effectuées avec des provenances de Petawawa (Ontario) de Fife Lake (Michigan) et de Big River (Saskatchewan), et le matériel obtenu a été planté à trois endroits sur un axe nord-sud en Ontario. Plus le caractère boréal de l'emplacement était prononcé, moins la survie était élevée à 8 ans. La survie des hybrides de provenance était intermédiaire par rapport à celle des plants issus des croisements intraprovenance. On a observé une hétérosis statistiquement significative pour la hauteur des arbres à deux endroits (écart par rapport au milieu des performances des descendances intraprovenance). À l'emplacement le plus au nord, l'accroissement a été médiocre, et aucune différence significative n'est apparue entre les familles (descendances biparentales). La qualité des microsites à l'intérieur des blocs n'étant pas homogène à deux endroits, il en est résulté une faible efficacité des blocs et une variation interplacettes hautement significative. Toutefois, avec cinq familles (descendances biparentales) par croisement, l'incidence sur l'analyse statistique des croisements est négligeable.

143. Magnussen, S.; Yeatman, C.W. 1988. Provenance hybrids in jack pine: 15-year results in eastern Canada. Silvae Genet. 37:206-218.

Results of height growth, stem form, injury, and branch angle at age 15 (16 in one case) are reported for 26 jack pine provenance hybrids and 16 control provenances on six sites in eastern Canada. Variations in stem form, tree status, and branch angle were comparable in hybrids and provenances, with greater differences among provenances and hybrids than between the two groups. Hybrid height growth adjusted for the effects of damage was, as a rule, intermediate to that of its control provenances; hybrids captured on an average 68% of the difference between control provenances. No hybrid exceeded significantly the best control provenance. Examples of hybrid or provenance tree heights in excess of results obtained with local unimproved seed sources were very rare. A strong genotype X environment interaction of tree height on five sites could be isolated to 11 of the 37 tested entries. These entries had below average rank stability and above average regression coefficients of height versus local height. Hybrids had environmental stability intermediate to that of the control provenances.

144. Magnussen, S.; Yeatman, C.W. 1988. Theoretical basis for early testing in genetic improvement programs. Pages 53-67 *in* Boyle, T.J.B., ed. Proc. 21st Meeting of the Canadian Tree Improvement Association, Truro, N.S.

Calculations of genetic gain at rotation age in a trait arising from juvenile selection is simple in theory but hampered in practice due to insufficient knowledge about parameters in the gain equation. This paper points out the shortcoming of existing juvenile-mature correlation models and two alternative models are presented. A simulation study illustrates the impact of various temporal aspects of a breeding program on the optimum selection age; the standard error of the ensuing optimum ratio of juvenile to mature genetic gain per year is shown to be considerable. Nevertheless, juvenile selection appears to be superior to selection at maturity, even under less favourable conditions.

Il est simple en théorie de calculer les gains génétiques à l'âge de rotation pour une caractéristique surgissant d'une sélection d'arbres juvéniles, mais difficile à mettre cela en pratique à cause des connaissances insuffisantes sur les paramètres de l'équation des gains. Cet article souligne les lacunes des modèles actuels de corrélation juvénile-adulte, et deux modèles de rechange sont présentés. Une étude de simulation illustre les répercussions des divers aspects temporels d'un programme de reproduction sur l'âge optimum de sélection; l'erreur type du rapport optimum du gain génétique réalisé chaque année entre les arbres juvéniles et adultes est considérable. Néanmoins, il semble que la sélection juvénile soit supérieure à la sélection réalisée à la maturité, même dans des conditions moins favorables.

145. Magnussen, S.; Yeatman, C.W. 1989. Height growth components in inter- and intra-provenance jack pine families. Can. J. For. Res. 19:962-972.

Duration (D), rate of shoot elongation (RSE), number of stem units (NSU), and mean stem unit lengths (MSUL) of current year's (1987) leaders were analyzed in 18 jack pine (*Pinus banksiana* Lamb.) full-sib progenies from nine inter- and nine intra-provenance crosses. The parent material consisted of selected "plus" trees from Ontario, Québec, Wisconsin, and Michigan provenances. The average within-family variance (phenotypic) of D was on the average 186 days or twice as large as the among-family variance of 90 days. Duration was positively correlated with the number of growing degree-days at the place of parental origin. Tree height and height growth of several crosses significantly exceeded a local check lot, and the provenance effects on heights were predominantly additive (but not the luxuriance of hybrids). In determining annual height growth, it was discovered that D and RSE were roughly equally important, but large differences in RSE were observed among families with almost equal growth duration. The superior height growth of two interprovenance families was attributed to higher growth rates rather than a longer growth period. Although NSU was more important than MSUL in determining final shoot length, a negative correlation between NSU and MSUL complicated the overall significance of NSU. It was concluded that jack pine had sufficient variation in the examined height growth components to facilitate genetic improvement in height growth without adverse effects on periodicity. The provenance hybrids produced sufficiently promising results and additional exploitable phenotypic variation to warrant continued hybridization efforts.

La durée (D), la vitesse d'allongement des pousses (RSE), le nombre de tiges (NSU) ainsi que la longueur moyenne des tiges (MSUL) de pousses apicales de l'année (1987) ont été mesurés chez 18 doccondants biparentaux de Pin gris (*Pinus banksiana* Lamb.) de neuf hybrides d'interprovenance et neuf d'intraprovenance. Les parents étaient des arbres plus choisis parmi des provenances de l'Ontario, du Québec, du Wisconsin et du Michigan. La variance moyenne intra-familiale (phénotypique) de D était de 186 jours en moyenne, soit deux fois plus que la variance interfamiliale de 90 jours. Il existait une corrélation positive entre la durée et le nombre de degrés-jours de croissance de la région d'origine des parents. La hauteur des arbres et la croissance de plusieurs hybrides ont dépassé de manière significative celles des arbres sur un lot témoin, et les effets de la provenance sur les hauteurs étaient principalement additifs (pas de luxuriance des hybrides). La durée et RSE avaient à peu près autant d'importance l'une que l'autre pour déterminer la croissance annuelle, mais de grandes différences de RSE ont été observées d'une famille à l'autre alors que la durée de croissance était presque égale. L'accroissement supérieur des deux hybrides d'interprovenance a été attribué à des taux de croissance supérieurs plutôt qu'à une période de croissance supérieure. Même si le NSU avait plus d'importance que la MSUL dans la détermination de la longueur finale des pousses, une corrélation négative entre le NSU et la MSUL venait compliquer l'interprétation de la signification globale du NSU. Il est conclu qu'il y a suffisamment de variations chez le Pin gris entre les facteurs examinés qui agissent sur d'allongement sans effet adverse sur la périodicité. Les hybrides de provenance ont donné des résultats assez intéressants et une variation phénotypique additionnelle exploitable pour que les travaux d'hybridisation soient poursuivis.

146. Magnussen, S.; Yeatman, C.W. 1990. Predictions of genetic gain from various selection methods in open pollinated *Pinus banksiana* progeny trials. Silvae Genet. 39:140-153.

Variance components and heritabilities of tree height and stem diameter on three sites at age 6 and 14 are presented for 100 open pollinated *Pinus banksiana* (Lamb.) progenies. The progenies were sampled from two stands within each of five distinct areas (populations) in the Ottawa Valley, Ontario. Combining information from several sources into an index promised to double the expected genetic gain from selections based on single trait values. Family selection followed by within-family selection was less effective than index selection but superior to simple mass selection. Mass selection did not lead to a rapid loss of variation or inbreeding. The lack of significant G X E interactions and the absence of

important stand and area effects in the Ottawa Valley will facilitate the breeding programs in this commercially important species. Results at age 14 generally confirmed results obtained at age six.

147. Margolis, H.A.; Brand, D.G. 1990. Biochemical response of planted black spruce and jack pine seedling to silvicultural treatment. Page 163 *in* Titus, D.B. et al., eds. 1990. The silvics and ecology of boreal spruces. 1989 IUFRO Working Party S1.05-12 Symposium Proceedings. For. Can. Inf. Rep. N-X-271.

A large study was undertaken in 1986 with the objective of understanding how planted seedlings of two conifer species (black spruce and jack pine) would respond to changes in environmental conditions produced by some common silvicultural treatments. A brief report points out the differences found in the biochemical response of these two species to environmental manipulations.

148. Margolis, H.A.; Brand, D.G. 1990. An ecophysiological basis for understanding plantation establishment. Can. J. For. Res. 20:375-390.

Forest plantations in the early stages of establishment are considered as hierarchical biological systems, and some implications for the design of research projects and the education of regeneration foresters and scientists are discussed. Since less than optimum environmental conditions convey stress to seedlings, seedlings will in turn exhibit a strain response at either the biochemical, physiological, or morphological level. Environmental conditions in a clear-cut are contrasted with other regeneration niches, and implications for the performance of different plantation species are discussed. The important physiological and biochemical limitations on the absorption of water, nitrogen, and carbon by seedlings during their establishment phase are described. Methods of quantifying stress at the plantation site, including simple ways to separate seedling growth into its different physiological components, are shown. An example of an eastern white pine (*Pinus strobus* L.) plantation grown under different levels of soil temperature, fertilization, and brush control is presented to illustrate the concepts. An approach to silvicultural research is proposed that determines the effects of silvicultural treatment on the seedling environment and then relates these environmental conditions to seedling biochemistry, physiology, and growth.

Les premières étapes de l'établissement des plantations forestières sont considérées comme des systèmes biologiques hiérarchiques, et quelques implications de l'élaboration de projets de recherche et de l'éducation des forestiers et des chercheurs impliqués dans la régénération forestière sont discutées. Puisque des conditions environnementales sub-optimales induisent des stress aux semis, la réaction de ceux-ci se situe aux niveaux biochmique, physiologique ou morphologique. Les conditions environnementales d'une coupe à blanc sont comparées à d'autres systèmes de régénération, et les implications de la performance de diverses espèces utilisées pour la plantation sont discutées. Les limitations importantes aux niveaux physiologique et biochimique de l'absorption d'eau, d'azote et de carbone par les semis pendant leur phase d'établissement sont décrites. Des méthodes pour quantifier le stress sur des sites de plantation, incluant des façons simples de séparer la croissance des semis en diverses composantes physiologiques, sont présentées. Un exemple d'une plantation de pin blanc (*Pinus strobus* L.) établie sous différents niveaux de température du sol, de fertilisation et de compétition arbustive est donné pour illustrer ces concepts. On y propose une approche de recherche en sylviculture consistant à determiner les effets des traitements sur l'environnement et à relier ces conditions environnementales à la biochimie, la physiologie et la croissance des semis.

149. McAlpine, R.S. 1990. Seasonal trends in the Drought Code component of the Canadian Forest Fire Weather Index System/Évolution saisonnière de l'indice de sécheresse de la méthode canadienne de l'indice forêt-météo. PI-X-97E/F.

The Drought Code component of the Canadian Forest Fire Weather Index System is an indicator of long term drought and the associated impact on forest fire management. The Drought Code has definite seasonal trends, which can make interpretation of the current daily value difficult without a good frame of reference. Thirty five years of weather data from 35 selected weather stations across Canada were used to develop mean daily Drought Code average values for each weather station throughout the fire season. The graphs produced provide fire managers with daily mean Drought Code values and historical maximum values throughout the fire season, for comparison with observed daily Drought Code values.

L'indice de sécheresse de la Méthode canadienne de l'indice forêt-météo est un indicateur de la sécheresse à long terme et des répercussions de cette dernière sur la prévention et l'extinction des incendies de forêt. Or, cet indice subit sans contredit une évolutions saissonnière qui complique l'interprétation de la valeur journalière si l'on ne possède pas les points de repère voulus. 35 années de données météorologiques provenant de 35 stations météorologiques choisies dans l'ensemble du Canada ont servi à calculer la moyenne de l'indice journalier moyen de sécheresse à chacune de ces stations durant la saison des incendies. Les graphiques que l'on en tire donneront aux responsables de l'intervention contre l'incendie ou de l'aménagement par le feu la valeur journalière moyenne de l'indice de sécheresse et les maximums de ses antécédents durant la saison des incendies, pour qu'ils comparent ces valeurs à la valeur journalière observée.

150. McRae, D.J.; Flannigan, M.D. 1990. Development of large vortices on prescribed fires. Can. J. For. Res. 20:1878-1887.

A detailed set of data has been compiled on large fire whirlwinds occurring on prescribed burns conducted in Ontario. There appear to be two types of such whirlwinds: one occurs in pairs on the leeward side of the convection column and the other is created after the entire convection column begins to rotate. The second type occurs in association with very intense fires that may be described as fire storms. Fire whirlwind occurrence appears to be related principally to meteorological conditions in which wind speeds are less than 10 km/h, to the stability of the atmosphere up to 3000 m altitude, and to conditions where the amount of energy released from the fire is high. The roles of atmospheric stability, rate of energy release from the fire, and ignition pattern in the development of whirlwinds require further study.

Des données détaillées ont été réunis sur les gros tourbillons de feu qui se forment au cours de brûlages dirigés en Ontario. Il semble qu'il en existe deux types : ceux qui se produisent en double sous le vent du foyer central et ceux qui sont créés après que la colonne de convection a commencé à tourner. Ceux du deuxième type sont associés à des incendies très intenses qui peuvent être décrits comme des incendies tornades. Les tourbillons de feu semblent principalement se produire lorsque la vitesse des vents est inférieure à 10 km/h, que l'atmosphère est stable jusqu'à une altitude de 3000 m et que la quantité d'énergies libérée par l'incendie est élevée. Le rôle de la stabilité atmosphérique, de la quantité d'énergie dégagée par l'incendie et du patron d'allumage dans le développement de tourbillons exigera des études plus approfondies.

151. Mittal, R.K.; Anderson, R.L.; Mathur, S.B. 1990. Microorganisms associated with tree seeds: World Checklist 1990/Microorganismes associés aux graines d'arbre - Liste de référence mondiale 1990. PI-X-96E/F.

The Tree Seed Pathology Working Group was formed in 1981 by members of the Forest Tree & Shrub Seed Committee of the International Seed Testing Association (ISTA). Since the beginning the working group's objectives have been to test the effectiveness of tree seed health techniques, prepare results for ISTA Congress presentations, and evaluate potential testing techniques for inclusion in forest seed handbooks.

Literature on the microorganisms associated with tree seeds is available in diverse sources which are sometimes unavailable to seed researchers. Recognizing the need to collect all relevant information regarding distribution of tree seed pathogens around the world, Dr. Anderson published a checklist in 1986 which covered an extensive list of hosts, organisms, and countries.

Because of the continuous flow of new information such a work is never complete and the present publication updates the checklist. The value and usefulness of this revision is sure to be appreciated by nurserymen, pathologists, and entomologists throughout the world.

Le groupe de travail pathologique sur les graines d'arbre a été formé en 1981 par les membres du Comité des graines d'arbres et d'arbustes forestiers de l'Association internationale d'essais de semences (AIES). Dès le début, les objectifs du groupe de travail comprennent les essais d'efficacité de la technique concernant l'état de santé des graines, la présentation des résultats aux conférences de l'AIES et l'évaluation des méthodes potentielles à l'inclusion des manuels des graines forestières.

Il y a des documents traitant les microorganismes associés aux graines d'arbre, mais ils ne sont pas toujours à la disposition des chercheurs. Étant donné la nécessité de recueillir des informations pertinentes, le Dr. Anderson a publié une liste de référence qui comprenait les hôtes, les organismes et les pays.

À cause de l'accumulation continue de nouveaux renseignements, une telle publication n'est jamais complétée. C'est pourquoi on s'attend à ce que les pépiniéristes, les pathologistes et les entomologistes à travers le monde trouvent utile la présente publication revue.

152. Mittal, R.K.; Wang, B.S.P. 1989. Fungi on eastern white pine seeds with high moisture content can survive ultralow temperatures. Tree Planters' Notes. 40(4):34-36.

Inoculated fungi - *Fusarium sporotrichoides* Sherb and *Mucor hiemalis* Wehmer - on eastern white pine (*Pinus strobus* L.) seeds with high moisture content survived well after 35 days of storage at -18, -80, -145, and -196°C. This shows that storing tree seeds at ultralow temperatures will not eliminate fungal pathogens.

153. Monty, J. 1990. An 800 kW wood fuelled energy recovery plant. PNFI Technical Reports, No. 9.

154. Monty, J. 1990. Installation d'une tour d'observation pour le repérage des incendies de forêt. Rapports techniques de l'IFNP, n°. 2.

155. Monty, J. 1990. Installation of a single pylon forest fire lookout tower. PNFI Technical Reports, No. 2.

156. Moore, T.G.E.; Lockwood, C.G. 1990. The HSG wood supply model: description and user's manual. PI-X-98.

The authors briefly describe a planning system prepared to assist in the design and evaluation of long-range timber harvest schedules. The central component of this planning system is a wood supply model that operates by tracking the development of individual stands through time. The model retains the spatial identity of all stands through all forecasts and thus eliminates forecasting errors caused by aggregation. In areas where geography is an important factor in the design of feasible harvest schedules, the spatially-dependent rules in the harvest scheduling algorithm may substantially improve the feasibility of the computer generated forecasts. The first part of this report describes the features of the model, and the second part provides instructions on how to prepare datasets and operate the software.

Les auteurs décrivent un système d'organisation lequel a été préparé pour assister à la conception et à l'évaluation des périodes de récolte de bois à long terme. Le composant principal de ce système est un modèle de réserve de bois qui suit le développement de chacun des peuplements dans le temps. Dans le modèle sont inclus les paramètres géographiques de tous les peuplements pour toutes les prévisions. Grâce à ce fait, les erreurs de prévision causées par l'agrégation sont éliminées. Dans les secteurs où l'emplacement géographique joue un rôle important pour déterminer les périodes de récoltes possibles, les règles de l'algorithme qui établissent le plan de récolte et qui dépendent des paramètres géographiques peuvent améliorer substentiellement la possibilité des prévisions générées par l'ordinateur. La première partie du présent rapport décrit la caractéristique du modèle. Les instructions en vue de préparer les bases de données et de faire fonctionner le logiciel se trouvent dans la deuxième partie.

157. Murray, W.G. 1988. The role of bird dog officers in aerial fire suppression. PI-X-82.

A select number of Aerial Fire Operations Supervisors and Bird Dog Officers from Canadian Forest Fire Protection agencies were interviewed to identify operational procedures and the role of the Bird Dog Officer in aerial forest fire suppression. The present analysis deals with Bird Dog aircraft, communications, operational procedures, and the job qualifications of a Bird Dog Officer.

158. Murray, W.G. 1989. Rôle des aéropointeurs dans l'extinction aérienne des incendies de forêt. PI-X-82F. 17 p.

On a interviewé un certain nombre de responsables des opérations aériennes et d'aéropointeurs d'organismes canadiens de protection contre les incendies de forêt en vue de déterminer les méthodes opérationnelles employées et le rôle de l'aéropointeur dans l'extinction aérienne des incendies de forêt. Dans l'analyse présentée dans ce rapport, on se penche sur l'aéronef d'aéropointage, les communications, les méthodes opérationnelles et les qualités requises pour un emploi d'aéropointeur.

159. Newnham, R.M. 1988. A modification of the Ek - Payandeh nonlinear regression model for site index curves. Can. J. For. Res. 18:115-120.

A new nonlinear regression model for constructing site index curves is described that, unlike previous models based on the Chapman-Richards growth model, produces sets of curves that are constrained to pass through the appropriate height at the index age as well as through the origin. The model was tested on two sets of height-age data, one from published yield tables and the other from stem analyses, and was found to give a good fit in both cases. These was a minimum loss of accuracy compared with a similar, unconstrained model.

L'article présente la description d'un nouveau modèle de régression non linéaire permettant la construction de courbes d'indices stationnels de production. Contrairement aux modèles antérieurs, dérivés du modèle de croissance Chapman-Richards, ce modèle produit des séries de courbes contraintes de passer par la hauteur correspondant à l'indice d'âge ainsi que par le point d'origine. Testé pour deux séries de données hauteur-âge, l'une provenant de tables de production publiées et l'autre d'analyses de tiges, le modèle s'est montré juste dans les deux cas. La perte de précision est minime comparativement à celle des modèles analogues mais sans contrainte.

160. Newnham, R.M. 1988. A variable-form taper function. PI-X-83.

The theories that have been developed to account for stem form are briefly described, and published taper functions reviewed. A new taper function for red pine (*Pinus resinosa* Ait.) plantation trees is developed that allows for continuous variation in form along the stem. Form is expressed by the variable k in the relationship:

$$(d/D)K = (H - h)/(H - 1.30)$$

where D is the diameter at breast height (1.30 m), H the total height of the tree, and d the diameter at a height h on the stem. From stem analyses, estimates of k can be obtained at any point from ln[(H-h)/(H-1.30)]/ln(d/D). The relationship between k and relative height and D/H ratio is then calculated using standard regression methods. The two models that appear to be the most promising are:

$$k = 2.48 - 1.540X^6 - 0.696(D/H) + 0.770X^2.(D/H)$$

and $$k = 2.58 - 0.763(D/H) + 0.205X.(D/H)^2 - 0.244\ (1/h)$$

where X = (H-h)/(H-1.30). These models give accurate and relatively unbiased estimates of stem diameters that compare favourably with the estimates of the more complex Max-Burkhart segmented polynomial function. The two variable-form models give more accurate and less biased estimates of stem volume than those obtained using the Max-Burkhart model.

161. Newnham, R.M. 1989. Preliminary trials of the forest management model, FIRFOR. Pages 19-35 *in* Pritchard, M.A., ed. A systems approach to forest operations planning and control. Proc. IUFRO Working Group S3.04.01. Edinburgh. 1988.

The results of seven tests of the forest management simulation model, FIRFOR (Newnham 1988), in the jack pine working circle (31 541 ha) of a forest management unit in northern Ontario, are described. The tests illustrate the long-term (300 years) effects on the annual harvest of different management options. The annual cut may be prescribed by stand age, or may be controlled by volume (with an area check) or area (with a volume check). A proportion of any fire-damaged wood may be salvaged. The model may be used as an aid to the forest manager in developing forest management plans.

162. Newnham, R.M. 1990. Mesure du défilement de forme variable. PI-X-83F.

Les théories qui ont été élaborées pour tenir compte de la forme de la tige sont brièvement décrites, et l'on passe en revue les fonctions de mesure du défilement qu'on peut trouver dans la documentation publiée. Une nouvelle fonction, valable pour des arbres de plantations de pins rouges (*Pinus resinosa* Ait.), est présentée; cette fonction tient compte d'une variation continuelle de forme le long de la tige. La forme est exprimée par la variable k dans l'équation suivante :

$$(d/D)K = (H - h)/(H - 1,30)$$

où D est le diamètre à hauteur de poitrine (1,30 m), H est la hauteur totale de l'arbre et d est le diamètre à une hauteur h, le long de la tige. Par des analyses de la tige, on peut obtenir des estimations de k à n'importe quel point en exprimant l'équation comme suit : $k = \ln[(H - h)/(H - 1{,}30)]/\ln(d/D)$. La relation entre k et la hauteur relative ainsi que le rapport D/H est alors calculé au moyen de méthodes de régression normales. Les deux modèles qui semblent les plus prometteurs sont les suivants :

$$k = 2{,}48 - 1{,}540X^6 - 0{,}696(D/H) + 0{,}770X^2.(D/H)$$

$$\text{et } k = 2{,}58 - 0{,}763(D/H) + 0{,}205X.(D/H)^2 - 0{,}244\ (1/h)$$

où $X = (H-h)/(H-1{,}30)$. Ces modèles fournissent des estimations précises et relativement non biaisées des diamètres de la tige, lesquelles se comparent avantageusement avec les estimations obtenues au moyen de la méthode plus complexe faisant appel à la fonction polynômiale segmentée de Max-Burkhart. Les deux modèles de défilement de forme variable donnent des estimations plus exactes et moins biaisées du volume de la tige que celles obtenues avec le modèle de Max-Burkhart.

163. Nieman, T.C. 1990. Development and use of portable data recorders in North American forestry. Bull. Rech. Agron. Gembloux 25:139-151.

The author provides information on developments in forestry electronic data capture systems during the past decade in Canada and the USA, with particular attention to PDR's, and analyzes the potential of this technology in terms of time and cost savings.

164. Nieman, T.C. 1990. Portable data recorder developments in forestry: an update. The Compiler 8(1):13-22.

A review of the latest electronic data capture instruments available to the forestry community, with comments on the advantages or disadvantages of various features.

165. Nieman, T.C.; Boyle, T.J.B. 1989. Estimates of genetic parameters for a Norway spruce population after intensive mass selection. Pages 124-141 *in* Stener, L.-G.; Werner, M., eds. 1989. Norway spruce; provenances, breeding and genetic conservation. Proc. IUFRO Wk. Party Meeting S2.02-11, Uppsala. Inst. för Skogsförbättring, Report No. 11.

A Norway spruce (*Picea abies* L. Karst) population of German origin was planted in 1924 at the Petawawa National Forestry Institute, Chalk River, Ontario, Canada. The original population of 1500 trees was subjected to intensive mass selection for winter hardiness following a very severe winter in 1933-34. After subsequent roguing based on hardiness and weevil tolerance, the population was reduced to only 29 trees by 1942. From this material, three open-pollinated progeny tests were established. A control-pollinated progeny test, originating from a second generation plantation of the original population and European provenances in a IUFRO test, was planted in 1972.

Height, diameter, weevil, and frost damage were measured and assessed in the progeny tests between the ages of 18 and 20 years. Measurements at ages 32, 52, and 68 years were available for trees in the original population. Results showed that growth rate compared favorably with local white spruce plantations and exceeded that of superior Norway spruce provenances in the 1939 IUFRO test, thus reflecting the effectiveness of mass selection.

Strong genetic control was demonstrated for weevil tolerance and frost hardiness, while heritability estimates for height and diameter were comparable to those for other species. Significant genotype x environment interaction for height was evident. Genetic correlations among all traits were significant, but the sign of the correlation between height and weevil tolerance differed between the

selected and European material. Selection indices estimated for the various populations indicated a substantial loss of gain potential through several generations of selection.

166. Péch, Gy. 1989. A model to predict the moisture content of reindeer lichen. For. Sci. 35:1014-1028.

The Fine Fuel Moisture Code (FFMC) of the Canadian Forest Fire Weather Index System is modified to apply to the top layers of reindeer lichen (*Cladina rangiferina* [L.] Nyl.). While the basic assumption for FFMC, i.e., exponential drying in constant weather influenced by relative humidity, air temperature, and wind, is retained in the calculation of the reindeer lichen moisture code, actual drying in the model is accelerated by isolation. The equilibrium moisture content (E) of sun-exposed reindeer lichen is 3-4% lower than that for shaded fuels. Rainfall causes a more rapid rise of moisture content in reindeer lichen than in FFMC, and the change is proportional to the initial (M_0) and saturation (M_s) moisture contents of the lichen, and the amount of rain (R). The model postulates that after rain the moisture content of the lichen (M_r) is:

$$M_r = M_0 + [a(M_s - M_0)/(a + M_0)][1 - e^{-B(M_s - M_0)R}]$$

Comparison of experimental measurements with calculated values suggests that the model represents moisture content in the top 3-4 cm layer of reindeer lichen.

167. Penner, M. 1989. Optimal design with variable cost and precision requirements. Can. J. For. Res. 19:1591-1597.

A method for incorporating variable costs and differing precision requirements into optimal design theory is developed and discussed. In many studies and experiments, particularly in the biological sciences, the cost of each observation can vary considerably depending on the attributes of the sample. Ignoring observation costs leads to designs that maximize precision for a given sample size. However, by incorporating costs, efficiency is maximized by optimizing precision per unit cost. An example is presented that demonstrates the efficiency of a weighted optimal design in comparison with several alternatives. The weighted optimal design is most efficient at meeting the experimenter's precision objectives. Comparing designs allows the introduction of additional criteria such as design flexibility into the evaluation process. Explicitly incorporating both cost and precision in the search for a sampling design ensures time is wisely spent considering study objectives, including precision requirements.

L'auteure décrit une méthode permettant d'intégrer des coûts variables et des exigences différentes de précision dans l'optimisation des plans d'expérience. Dans beaucoup d'études et d'expériences, particulièrement en sciences biologiques, le coût de chaque observation peut varier considérablement selon les attributs de l'échantillon. En négligeant de prendre en considération les coûts, on obtient des plans qui maximisent la précision en fonction de la taille de l'échantillon. En intégrant les coûts, on maximise l'efficacité, la précision étant optimisée en fonction du coût unitaire. L'auteure présente un exemple qui démontre l'efficacité d'un plan optimal pondéré par rapport à plusieurs autres plans possibles. Avec un tel plan, les objectifs de précision de l'expérimentation sont atteints avec le maximum d'efficacité. La comparaison de divers plans permet d'introduire des critères additionnels, comme la souplesse des plans, dans le processus d'évaluation. L'inclusion des critères explicites de coût et de précision dans la recherche d'un plan d'échantillonnage assure que le temps est judicieusement consacré aux objectifs de l'étude, y compris les exigences relatives à la précision.

168. **Périnet, P.; Vallée, G.; Tremblay, F.M. 1988. *In vitro* propagation of mature trees of *Alnus incana* (L.) Moench. Plant Cell, Tissue Organ Cult. 15:85-89.**

Mature trees of European grey alder (*Alnus incana*) were micropropagated on a modified MS medium containing 2.5 µM BA, 6.2 mM (500 mg l^{-1}) NH_4NA_3 and 1.5% glucose. Prior to *in vitro* culture, mature scions were multiplied through grafting and cutting techniques. Shoot tips from cuttings were established *in vitro*. After six months of culture, shoots were rooted either *in vitro* or *in vivo* and plantlets were transferred to greenhouse conditions.

169. **Petawawa National Forestry Institute. 1988. Program review 1987-1988.**

170. **Petawawa National Forestry Institute. 1988. Recent Achievements at Petawawa. March 1988.**

171. **Petawawa National Forestry Institute. 1988. Recent Achievements at Petawawa. December 1988.**

172. **Petawawa National Forestry Institute. 1989. Program review 1988-1989.**

173. **Petawawa National Forestry Institute. 1989. Recent Achievements at Petawawa. August 1989.**

174. **Petawawa National Forestry Institute. 1990. Recent Achievements at Petawawa. April 1990.**

175. **Petawawa National Forestry Institute/Institut forestier national de Petawawa. 1990. Petawawa National Forestry Institute/Institut forestier national de Petawawa. Pamphlet/Brochure.**

A colour brochure detailing the Institute's programs./Une brochure en couleurs, décrivant les programmes de recherches de l'Institut.

176. **Pitel, J.A.; Cheliak, W.M. 1988. Metabolism of enzymes with imbibition and germination of seeds of jack pine (*Pinus banksiana*). Can. J. Bot. 66:542-547.**

The level of soluble proteins and the total activities of 14 enzymes were determined in embryo and megagametophyte tissues of jack pine (*Pinus banksiana* Lamb.) seeds during imbibition and germination. For embryos, enzyme activities were low in the dry seed and during imbibition but increased rapidly upon germination following emergence of the radicle and to the end of the sampling period of 13 days. For gametophytes, enzyme activities generally increased at a slower rate than embryos, with highest activity present for seeds after 8-10 days of germination. Levels of soluble protein in the gametophytes were highest shortly after emergence of the radicle, while for the embryos levels were highest at the end of the germination period.

Le niveau des protéines solubles et les activités totales de 14 enzymes ont été étudiés dans les tissus embryonnaires et mégagamétophytes des graines du pin gris (*Pinus banksiana* Lamb.) durant l'imbibition et la germination. Les activités enzymatiques des embryons étaient faibles dans les graines sèches et durant l'imbibition mais elles augmentaient rapidement à la germination après la percée de la radicule et jusqu'à la fin de la période d'échantillonnage d'une durée de 13 jours. Pour les gamétophytes, les activités enzymatiques ont, en général, augmenté plus lentement que chez les embryons; l'activité la plus élevée ayant été mesurée dans les graines 8 à 10 jours suivant la germination. Les niveaux de protéines solubles dans les gamétophytes étaient plus élevés peu de temps après la sortie de la radicule, alors que pour les embryons, les niveaux étaient plus élevés à la fin de la période de germination.

177. Pitel, J.A.; Cheliak, W.M. 1989. Some protocols for cDNA library construction with conifer tissues. PI-X-95.

This handbook presents various protocols for constructing cDNA libraries using conifer or other plant tissue as a source. Included are methods for RNA extraction that vary in terms of buffer composition, length of time for extraction, the requirement for ultracentrifugation, the degree of purification, and others. Methods for separating messenger (m) RNA from ribosomal (r)RNA, electrophoresis of mRNA, and Northern blotting are described.

For cDNA library construction, methods are presented for first and second strand synthesis, isolation of high molecular weight cDNA, electrophoresis of cDNA, ligation reactions to the vectors; extraction of insert cDNA from the vector, etc.

Also included is information that may be useful for those starting to work in this field, such as addresses for suppliers of chemicals and equipment, recipes for stock solutions, references for more detailed information, and suggestions from our experience as to which method might be successful for different tissues and species.

178. Pitel, J.A.; Cheliak, W.M. 1990. Procédés de création de banques d'ADNc de tissus de conifères. PI-X-95F.

Dans ce manuel, on décrit divers procédés permettant de constituer des banques d'ADNc à partir de tissus de conifères ou d'autres plantes. On donne des méthodes d'extraction de l'ARN se distinguant par la composition du tampon, la durée de l'extraction, la nécessité de l'ultracentrifugation, le degré de purification et divers autres aspects. On expliqe aussi comment séparer l'ARNm (messager) de l'ARNr (ribosomique), comment réaliser l'électrophorèse de l'ARNm et le transfert de Northern.

En ce qui a trait à la constitution d'une banque d'ADNc, on décrit des méthodes de synthèse du premier et du second brin, l'isolement de l'ADNc de masse moléculaire élevée, l'électrophorèse de l'ADNc, la ligature au vecteur, l'extraction de l'ADNc inséré dans le vecteur, etc.

Enfin, on donne des renseignements qui seront peut–être utiles à ceux qui commencent à travailler dans le domaine. Y sont inclus notamment une liste des adresses des fournisseurs de produits chimiques et d'équipement, des recettes de solutions-mères, des sources d'information plus détaillée et des conseils quant aux méthodes qui, d'après notre expérience, devraient donner les meilleurs résultats selon le type de tissu ou l'espèce.

179. Pitel, J.A.; Cheliak, W.M.; Wang, B.S.P. 1989. Some biochemical changes associated with stratification and germination of basswood seeds. Seed Sci. Technol. 17:57-71.

The metabolism of soluble amino acids, soluble proteins, and enzymes of embryo and endosperm tissues of basswood seeds following stratification at 4°C or 20°C was examined. Levels of soluble protein and concentration of the soluble amino acids of embryo and endosperm tissues increased gradually for seeds stratified at 4°C, and were higher than for seeds stratified at 20°C. Significant fluctuations in the percentage distribution of various amino acids were observed for seeds stratified at both 4°C and 20°C. The activities of malate dehydrogenase (NAD^+-MDH), glucose-6-phosphate dehydrogenase (G-6-PD), 6-phosphogluconic acid dehydrogenase (6-PGD), and isocitrate dehydrogenase ($NADP^+$-IDH) for embryos increased gradually with stratification at 4°C and were higher than for seeds stratified at 20°C. For peroxidase (PER), activites increased dramatically near the end of the stratification period, with those stratified at 20°C having more activity.

Le métabolisme des acides aminés libres, des protéines solubles et d'enzymes des tissus de l'embryon et de l'albumen des semences de tilleul d'Amérique a été étudié au cours d'une stratification à 4°C ou à 20°C. La teneur en protéines solubles et la concentration en acides aminés libres des tissus de l'embryon et de l'albumen augmentaient progressivement pour les semences stratifiées à 4°C et étaient plus élevées que pour les semences stratifiées à 20°C. Des variations significatives de la teneur en différents acides aminés ont été observées avec les semences stratifiées à 4°C et à 20°C. L'activité de la malate déshydrogénase ($NADP^+$-MDH), de la glucose 6-phosphate déshydrogénase (G-6-PD), de la 6-phosphogluconate déshydrogénase (6-PGD) et de l'isocitrate déshydrogénase ($NADP^+$-IDH) des embryons augmentait progressivement pendant la stratification à 4°C et était plus élevée que pour les semences stratifiées à 20°C. En ce qui concerne les peroxydases (PER), leur activité augmentait considérablement vers la fin de la période de stratification et cette activité était plus grande chez les semences stratifiées à 20°C.

180. Pitel, J.A.; Wang, B.S.P. 1988. Improving germination of basswood (*Tilia americana* L.) seeds with gibberellic acid. Seed Sci. Technol. 16:273-280.

The effects of sulphuric acid scarification followed by incubation with a solution of kinetin and gibberellic acids (GA_3 and GA_{4+7}), or a combination of potassium nitrate and thiourea, on the germination of three seed lots of basswood (*Tilia americana*) were studied. Both the rate and percentage of germination were increased, by treatment of acid-scarified seeds with kinetin and gibberellic acid, over that of untreated scarified seeds. For the three seedlots examined, over 90% germination was obtained after 60-80 days at 4°C. When the seeds were collected in early fall before seed coats became impermeable, high germination (over 90%) occurred without prior acid scarification or hormone treatment. The best physiological state of the fruits occurred when seed moisture content was about 58% and the fruits were starting to turn grey-brown. The following regime is recommended for maximum germination of mature seed: the pericarps be removed and seeds soaked in sulphuric acid for 15-20 minutes; seeds should be washed for several minutes with water and then imbibed in water for 24 hours; seeds should be soaked in a solution of kinetin (1 mg/L) and gibberellic acid (GA_3, 500 mg/L); lastly germination should be at 4°C in the dark for 2-2 1/2 months.

On a étudié les effets d'une scarification à l'acide sulfurique, suivie d'une incubation avec une solution de kinétine et de gibbérellines (GA_3 et GA_{4+7}) ou avec un mélange de nitrate de potassium et de thiourée, sur la germination de trois lots de semences de tilleul (*Tilia americana* L.). La vitesse et le pourcentage de germination augmentaient à la suite du traitement par la kinétine et l'acide gibbérellique des semences scarifiées à l'acide, par rapport aux semences scarifiées non traitées. Pour les trois lots de semences examinés, on a obtenu plus de 90 % de germination après 60 à 80 jours à 4°C. Quand on récoltait les semences précocement, avant que les téguments deviennent imperméables, une forte germination (plus de 90 %) avait lieu sans scarification préalable par l'acide ni traitement hormonal. Le meilleur état physiologique des fruits correspondait à une teneur en eau des semences voisine de 58 % et à des fruits commençant à virer au brun-gris. On recommande la méthode suivante pour obtenir une germination maximale des semences mûres: enlever les péricarpes et tremper les graines dans de l'acide sulfurique pendant 15 à 20 minutes; les graines doivent être lavées pendant plusieurs minutes avec de l'eau, puis imbibées dans l'eau pendant 24 h; elles doivent ensuite être trempées dans une solution de kinétine (1 mg/L) et d'acide gibbérellique (GA_3, 500 mg/L); enfin, la germination doit s'effectuer à l'obscurité, à 4°C, pendant 2 à 2 1/2 mois.

181. Power, J.M. 1988. Decision support systems for the Forest Insect and Disease Survey and for pest management. For. Chron. 64:132-135.

Effective forest pest management involves decision-making supported by useful information. The concept of Decision Support Systems is being actively pursued by the Forest Insect and Disease Survey (FIDS) of the Canadian Forestry Service to meet its information needs for analysis of forest pest conditions. The FIDSINFOBASE system was developed to provide FIDS units nationwide access to survey data. Geographic Information System capabilities are being integrated for capture and analysis of infestation maps. Possibilities exist for the integration of systems, data, and models among agencies for information standardization and exchange.

Une gestion efficace des ravageurs forestiers suppose une prise de décisions basée sur l'information pertinente. La Direction du Relevé des insectes et des maladies des arbres (RIMA) au sein du Service canadien des forêts s'intéresse activement aux systèmes d'aide à la décision pour l'obtention de l'information dont elle a besoin pour l'analyse des conditions relatives aux ravageurs forestiers. Le système FIDSINFOBASE a été élaboré afin que les équipes du RIMA dans tout le pays puissent avoir accès aux données des relevés. Des fonctions de systèmes d'information géographique sont intégrées pour la saisie et l'analyse des cartes d'infestation. Il est possible d'intégrer les systèmes, données et modèles de divers organismes pour uniformiser et échanger des données.

182. Power, J.M.; Williams, D.H. 1988. Qualités requises et sélection d'un système d'information géographique national pour le Relevé des insectes et des maladies des arbres. PI-X-75F.

Le Relevé des insectes et des maladies des arbres (RIMA) peut utiliser des systèmes d'information géographique pour automatiser au niveau national la production de cartes d'infestation et analyser les paramètres spatiaux de l'interaction des insectes et des maladies avec les forêts. À la suite de la détermination des besoins pour le traitement des données spatiales, des systèmes d'information géographique utilisables avec des micro-ordinateurs ont été choisis pour les équipes régionales du RIMA.

Geographic Information Systems can be used by the national Forest Insect and Disease Survey (FIDS) to automate infestation map production and to analyze the spatial qualities of insect and disease interaction with the forest. The identification of requirements for spatial data handling resulted in the selection of microcomputer-based Geographic Information Systems for distribution to FIDS regional units.

183. Rogers, D.L. 1990. The black spruce clonal program: recent developments and future direction. Pages 1-6 *in* Rogers, D.L., ed. 1990. Proc. Ann. Meeting, Black spruce clonal forestry program. OMNR, Timmins, Ont.

The black spruce clonal program is one of the most exciting programs in which the Northern Forest Development Group (NFDG) is involved. It is based on cooperation among the public and private sectors, management, and research communities. The contributions from each of the cooperators are all essential to the success of the program. Given the genetic variation apparent in growth in natural populations of black spruce (at the individual level), and the cultural success in propagating it vegetatively, there is good reason to be very optimistic about the longer term, practical gains from this program. It continues to have the distinction of being one of perhaps eight conifer clonal programs in North America producing significant (i.e., >100 000) numbers of rooted cuttings per annum.

184. Schnekenburger, F.; Yeatman, C.W. 1988. Preliminary assessment of Japanese larch (*Larix leptolepis* [Sieb. and Zucc.] Gord.) established for land race development in eastern Ontario. Page 187 *in* Morgenstern E.K.; Boyle, T.J.B., eds. Proc. 21st Meeting CTIA Part II, Truro, N.S.

In 1980, two Japanese larch land race trials were established in eastern Ontario by the Ministry of Natural Resources in conjunction with Petawawa National Forestry Institute. The trials contain 79 seedlots collected from plantations, orchards and natural stands in Japan, Europe, and North America. Assessments were made in 1983 and 1986 for height and diameter growth. Mean seedlot heights in 1986 ranged from approximately 3.0 to 5.5 m; mean diameters ranged from approximately 3.0 to 8.0 cm. Variation among seedlots in terms of 1983 survival and 1986 growth was significant. Over half of the total variation was accounted for by individuals within seedlots. The trial will be progressively rogued and thinned over time and the best trees of the best families will be selected and used for seed collection.

185. Schooley, H.O.; Mullin, T.J. 1988. Seed production strategies: current vs. future. Pages 155-169 *in* Morgenstern, E.K.; Boyle, T.J.B., eds. Proc. 21st Meeting CTIA Part II, Truro, N.S.

Canadian statistics on conifer tree seed procured and utilized since 1978 are reviewed in relation to increased seed requirements for reforestation. Seed utilized increased from about 4.2 billion in 1978 to about 7.3 billion in 1984 and has continued to increase. Sufficient seed has been collected but most have originated from unimproved natural stands. Maximum annual production from seed collection and seed production areas was less than 12% of total seed production. The establishment of seed orchards has progressed at an accelerating rate in recent years and should exceed a total of 2000 ha by 1988. As these orchards become productive the supply of genetically improved seed will increase but, for many years, this supply is unlikely to exceed total seed requirements. Seed collection and seed production areas are the preferred seed sources to satisfy the deficiency between available orchard seed and total seed required.

On étudie les statistiques canadiennes sur les graines de conifères obtenues et utilisées depuis 1978 en relation avec les besoins croissants de graines pour le reboisement. Le nombre de graines utilisées est passé de 4200 millions en 1978 à environ 7300 millions en 1984 et n'a cessé d'augmenter. On a récolté suffisamment de graines, mais la plupart proviennent de peuplements naturels non améliorés. La production annuelle maximale réalisée à partir de zones de production et de récolte de graines était inférieure à 12 % de la production totale de graines. L'établissement de vergers à graines a progressé à un rythme accéléré ces dernières années et devrait dépasser 2000 ha avant 1988. À mesure que ces vergers deviendront productifs, les réserves de graines génétiquement améliorées continueront d'augmenter, mais ces réserves ne dépasseront probablement pas tous les besoins en graines avant de nombreuses années. Les zones de production et de récolte de graines sont les sources préférées pour combler la différence entre les graines de vergers disponibles et le total de graines nécessaires.

186. Simon, M.; Zsuffa, L.; Burgess, D. 1990. Variation in N, P, and K status and N efficiency in some North American willows. Can. J. For. Res. 20:1888-1893.

Differences in N, P, and K status and N efficiency of some North American willow species and their clones were observed and evaluated. *Salix eriocephala* Michx., *S. lucida* Mühl., and *S. exigua* Nutt., represented by five clones each, were raised from cuttings in potted loamy sand for 113 days. Plants were subjected to three levels of fertilization (equivalent to 125, 250, or 500 kg N/ha) applied at exponential rates of addition (0.06, 0.071, and 0.082, respectively), using complete nutrient solutions and were compared with control plants (no fertilizer added). The experiment showed that nutrient concentration and nutrient uptake in the plants depended not only on treatments but also on species and clones. Thus, species and clones that removed smaller amounts of nutrients per unit of biomass could be

selected. Species had a larger effect than clones on nutrient concentration and content. Total nutrient content, at the same treatment level, depended primarily on biomass production. Significant variation existed among species and clones in the ratio of biomass/total N. *Salix eriocephala* (the best species) produced 35.1% more than the other species, and the best experimental clones within species produced 27.8-41.6% more stem per unit of N than the poorest clones.

Des différences dans les status en N, P et K et l'efficacité de N ont été observées et évaluées dans quelques espèces (et leur clones) de saules d'Amérique du Nord. *Salix eriocephala* Michx., *S. lucida* Mühl. et *S. exigua* Nutt., représentés par cinq clones chacun, ont été cultivés en pots à partir de boutures pour une période de 113 jours. Les plants ont été soumis à trois niveaux de fertilisation (équivalent à 125, 250 ou 500 kg N/ha) appliqués à des taux exponentiel d'ajout (0,06; 0,071 et 0,082 respectivement) en utilisant des solutions nutritives complètes et ont été comparés à des plants témoins (sans ajout de fertilisant). L'expérience a montré que les concentrations d'éléments et les prélèvements d'éléments dans les plants ne dépendaient pas seulement des traitements mais aussi des espèces et des clones. Les espèces et les clones pourraient donc être sélectionnées sur la base des plus petites quantités prélevées par unité de biomasse. Les espèces ont eu un effet plus grand que les clones quant à la concentration et le contenu en éléments nutritifs. Le contenu total en éléments nutrifis, pour un même niveau de traitement, a été fonction principalement de la production de biomasse. Des variations significatives ont été observées entre les espèces et les clones dans le ratio biomasse/N total. *Salix eriocephala* (la meilleure espèce) a produit 35,1 % plus que les autres espèces et les meilleurs clones ont produit 27,8-41,6 % plus de tige par unité de N que les clones les moins performants.

187. Singh, P.; Mittal, R.K. 1989. Influence of seed-borne fungi on the nutrient composition and growth of conifer seedlings. Eur. J. For. Path. 19:65-77.

The present investigations have shown that inoculation of seeds of white pine and white spruce with four different seedborne fungi (*Cladosporium cladosporoides, Fusarium sporotrichioides, Mucor hiemalis, Trichothecium roseum*) does effect the nutrient levels, the total height growth, and biomass of seedlings of the two conifer species. The fungi seem to induce considerable changes in the physiology of the seedling development, which result in the increase or decrease in the concentrations of various macro- and micronutrients (N, P, K, Mg, Na, Ca, Mn, Fe, and Zn). The response of each nutrient and each species to each fungus varied and there was no apparent relationship between the changes in nutrient levels and reduction of height growth or the biomass. It is, however, suggested that these fungi cause some kind of interference in the normal physiology of germination and seedling development, including absorption or translocation of nutrients, which results in the depletion of some ions or accumulation of the others; these physiological disturbances eventually may affect the height growth, biomass, and vigour of seedlings.

Il a été montré que l'inoculation de graines de *Pinus strobus* et de *Picea glauca* avec quatre champignons de semences (*Cladosporium cladosporoides, Fusarium sporotrichioides, Mucor hiemalis, Trichothecium roseum*) agit sur les teneurs en éléments nutritifs, la croissance en hauteur et la biomasse des semis. Les champignons semblent induire des changements considérables dans la physiologie du développement des semis, qui aboutissent à l'augmentation ou diminution de la concentration des macro- et microéléments (N, P, K, Mg, Na, Ca, Mn, Fe, Zn). La réponse varie pour chaque élément et pour chacun des espèces vis-à-vis des divers champignons et il n'y a apparemment pas de relation entre les changements de teneurs en éléments nutritifs et la réduction de croissance ou de biomasse. Il est cependant suggéré que ces champignons ont une certaine influence sur la physiologie normale de la germination et du développement des semis, y compris l'absorbtion ou la translocation des éléments nutritifs, qui aboutit à l'appauvrissement en certains ions ou à l'accumulation d'autres; ces perturbations physiologiques peuvent éventuellement affecter la croissance en hauteur, la biomasse et la vigueur des semis.

188. **Smith, N.J.; Brand, D.G. 1988. Compatible growth models and stand density diagrams. Pages 636-643 *in* Ek, A.R. et al., eds. Proc. IUFRO Conf. Forest Growth Modelling and Prediction. Vol. 2. Minneapolis, MN. Soc. Am. Foresters Publication SAF 87.12.**

A stand average growth model based on the self-thinning rule is developed and used to generate stand density diagrams. The model is tested on plantation data from 15 remeasured red pine (*Pinus resinosa* Ait.) permanent sample plots. For total stem volume (m^3/ha) versus numbers of stems per ha the slope was 1.39 and the intercept 10350 m^3/ha/tree. Incipient mortality occurred at a relative density (RD) of 0.04, maximum current annual increment at 0.51 RD and maximum mean annual increment at 0.82 RD. Diameter distributions were 'recovered' from any point on the diagram using the Weibull distribution.

189. **Stechishen, E. 1990. Emploi d'un mélangeur pour contrôler la qualité des agents moussants. Rapports techniques de l'IFNP, n° 3.**

190. **Stechishen, E. 1990. Surfactant qualities of forest fire fighting foams. PNFI Technical Reports, No. 8.**

191. **Stechishen, E. 1990. Using a blender to do quality checks of foaming agents. PNFI Technical Reports, No. 3.**

192. **Stechishen, E. 1990. The wetting ability of forest fire foam. PNFI Technical Reports, No. 6.**

193. **Stiell, W.M. 1988. Consistency of cone production in individual red pine. For. Chron. 64:480-484.**

A plantation of red pine (*Pinus resinosa* Ait.) produced heavy cone crops in 1970 and 1984. Established at 6.5 x 6.5 m, the stand was 18-years-old in 1970 and still open-grown; crowns were closed before 1984. Cone production at the two dates was compared for 28 trees. While total production was similar for 1970 and 1984, distribution within the sample differed. Although 18% of the trees maintained their rank in 1984, some large changes in production ranking took place from one crop to the next. Despite a tendency at both dates for crop size to increase with current dbh, exceptions were evident and the largest trees did not necessarily bear the most cones. Crop size in 1970 was the variable most closely associated with 1984 crop size and was significantly correlated with it independently of 1984 dbh. High cone production did not seem to depress tree growth, based on a comparison of 1970-72 basal area increment of more versus less prolific cone bearers. Before a stand has borne its first good cone crop, expectations for highest yields would have to be based on tree size. For subsequent crops, previous production by individuals would be the best guide. The two top cone bearers far surpassed all others in both crop years and would be the first individuals selected for seed trees in a seed production area.

Une plantation de pins rouges (*Pinus resinosa* Ait.) a produit de grandes quantités de cônes en 1970 et 1984. Établie à un espacement de 6,5 x 6,5 m, la plantation avait 18 ans en 1970, et chaque arbre croissait encore comme étant situé en milieu ouvert. Cependant, le couvert s'est renfermé avant 1984. On a comparé la production de cônes des deux années pour 28 arbres. Tandis que la production totale était comparable en 1970 et 1984, la distribution de production de chaque échantillon a changé. Même si 18 % des arbres ont maintenu leur rang productif en 1984, des changements substantiels se sont produits d'une récolte à l'autre. En dépit du fait que la taille de la récolte des deux années tendait à augmenter avec le dhp, de nombreuses exceptions ont pu être mises en évidence. Les arbres les plus larges n'ont pas nécessairement produit les plus grands nombres de cônes. La taille de la récolte en 1970 était la variable la plus fortement associée avec celle de 1984. Cette corrélation était très significative même si le dhp en 1984 ne l'était pas. La très grande production de cônes ne semble pas avoir diminuée la croissance des arbres. Cette constatation est basée sur une comparaison de croissance en surface terrière de 1970 à 1972 entre des arbres produisant de faibles quantités de cônes et ceux qui sont de bons producteurs. Avant qu'un peuplement produise sa première génération de cônes, la prédiction de grandes récoltes doit être basée

sur la taille de l'arbre. Pour les récoltes subséquentes, les productions précédentes de chaque individu constituent le meilleur guide. Les deux meilleurs producteurs de cônes ont surpassé de loin tous les autres arbres au cours des deux années et devraient être les premiers individus sélectionnés comme arbres semenciers dans une aire de production de graines.

194. **Stocks, B.J.; Lawson, B.D.; Alexander, M.E.; Van Wagner, C.E.; McAlpine, R.S.; Lynham, T.J.; Dubé, D.E. 1989. The Canadian Forest Fire Danger Rating System: An Overview. For. Chron. 65:450-457.**

Forest fire danger rating research in Canada was initiated by the federal government in 1925. Five different fire danger rating systems have been developed since that time, each with increasing universal applicability across Canada. The approach has been to build on previous danger rating systems in an evolutionary fashion and to use field experiments and empirical analysis extensively. The current system, the Canadian Forest Fire Danger Rating System (CFFDRS), has been under development by Forestry Canada since 1968. The first major subsystem of the CFFDRS, the Canadian Forest Fire Weather Index (FWI) System, provides numerical ratings of relative fire potential based solely on weather observations, and has been in use throughout Canada since 1970. The second major subsystem, the Canadian Forest Fire Behavior Prediction (FBP) System, accounts for variability in fire behavior among fuel types (predicting rate of spread, fuel consumption, and frontal fire intensity), was issued in interim form in 1984 with final production scheduled for 1990. A third major CFFDRS subsystem, the Canadian Forest Fire Occurrence Prediction (FOP) System, is currently being formulated. This paper briefly outlines the history and philosophy of fire danger rating research in Canada discussing in detail the structure of the current CFFDRS and its application and use by fire management agencies throughout Canada.

La recherche sur l'évaluation des dangers d'incendie de forêt au Canada a été initiée par le gouvernement fédéral en 1925. Cinq différentes méthodes d'évaluation des dangers d'incendie ont depuis été développées, chacune permettant un nombre croissant d'applications universelles à travers le Canada. L'approche a consisté à construire d'une manière évolutive à partir des méthodes d'évaluation des dangers précédentes, tout en faisant un usage important des expériences de terrain et de l'analyse empirique. La méthode actuelle, la Méthode canadienne d'évaluation des dangers d'incendie de forêt (MCEDIF), est en développement au ministère de Forêts Canada depuis 1968. La première sous-méthode majeure de la MCEDIF, la Méthode canadienne de l'indice forêt-météo (IFM), qui produit des évaluations numériques du potentiel relatif d'incendie, fondé uniquement sur des observations météorologiques, est utilisée à travers le Canada depuis 1970. La deuxième sous-méthode majeure, la Méthode canadienne de prévision du comportement des incendies de forêt (PCI) qui tient compte de la variabilité du comportement du feu en fonction des différents types de combustibles (prévoyant la vitesse de propagation, la consommation du combustible, l'intensité du front de flammes), a été publiée dans une forme intérimaire en 1984, sa production finale étant prévue pour 1990. Une trosième sous-méthode majeure de la MCEDIF, la Méthode canadienne de prévision de la naissance d'un incendie de forêt (PNI), est présentement en préparation. Ce texte souligne brièvement l'histoire et la philosophie de la recherche sur l'évaluation des dangers d'incendie au Canada, abordant en détail la structure de la MCEDIF actuelle ainsi que son application et son utilisation par les agences de gestion des feux de forêt à travers le Canada.

195. **Strome, W.M.; Leckie, D.G.; Miller, J.; Buxton, R. 1990. Application of high resolution remote sensing image data. Pages 77-93 *in* Shahroki, F., ed. 1990. Space commercialization: satellite technology. Proc. Symp. Amer. Ins. Aeronautics and Astronautics, Washington, DC, USA.**

There are many situations in which the image resolution of satellite data is insufficient to provide the detail required for resource management and environmental monitoring. This paper will focus on applications of high-resolution (0.4 to 10 m) airborne multispectral and imaging spectrometer data

acquired in Canada using the MEIS II multispectral line imager and the PMI imaging spectrometer. Applications discussed will include forestry, mapping, and geobotany.

196. Titus, S.J.; Morgan, D.J. 1988. Theory and methodology of single tree volume estimation/Théorie et méthodes d'estimation du volume individuel des arbres. PI-X-85E/F.

A revue of theory and methodology of single tree volume estimation is presented. Guidelines are discussed for dealing with (1) population definition, (2) sampling procedures, (3) measurement methods, and (4) curve-fitting techniques.

Ce rapport présente un examen de la théorie et des méthodes d'estimation du volume individuel des arbres. Il traite notamment de lignes directrices relatives 1) à la définition de la population, 2) aux méthodes d'échantillonnage, 3) aux techniques de mesure et 4) aux techniques d'ajustement de courbe.

197. Tremblay, F.M. 1988. Callus formation from protoplasts of *Betula papyrifera* March. cell suspension culture. J. Plant Physiol. 133:247-251.

Betula papyrifera callus and cell suspension cultures were established and maintained on Nagata and Takebe's medium (NT) supplemented with 2.5 µM 2,4-D. The growth patterns (FW and DW) of the cell suspensions were similar after four and 18 months in culture, but the yield of protoplasts increased with age of the suspension. The enzyme combination to isolate protoplasts affected the division frequency after 18 days in culture. Protoplasts isolated with 1% Cellulase Onozuka R-10 showed a higher division frequency than those isolated with a lower concentration. To culture birch prototplasts, the agarose bead technique combined with a NT-based medium was superior to liquid culture and allowed a higher frequency of microcallus formation and callus recovery.

198. Tremblay, F.M. 1990. Somatic embryogenesis and plantlet regeneration from embryos isolated from stored seeds of *Picea glauca*. Can. J. Bot. 68: 236-242.

White spruce (*Picea glauca*) embryogenic callus was obtained using 3- to 11-year-old seeds as a source of zygotic embryos. They were cultured on half-strength Litvay's medium supplemented with 10 µM 2,4-dichlorophenoxyacetic acid, 5 µM benzylaminopurine, 1 g/L casein hydrolysate, 500 mg/L glutamine, and 1% sucrose. The frequency of induction of embryogenic callus was significantly improved by incubation at 25°C and by a 4-h imbibition of the seeds. The yield of embryogenic callus was significantly affected by the geographic provenance of the seeds and by their number of years in storage. A significant correlation was also found between the yield of embryogenic callus and the percentage of germination of the seedlot used. Even after 11 years of storage, 40% of the zygotic embryos could produce an embryogenic callus when dissected from seeds with a high germination rate. Somatic embryos were matured after transfer onto an embryo development medium composed of the same medium but including 6% sucrose, 1 µM 2,4-dichlorophenoxyacetic acid, and 5 µM kinetin. The somatic embryos developed further under in vitro conditions and were then transplanted into soil. The somatic embryo-derived plantlets established in the greenhouse were similar to control plantlets obtained from germinated seeds. Mature embryos from stored seeds were shown to constitute a valuable source for white spruce somatic embryogenesis.

Du cal embryogène d'épinette blanche (*Picea glauca*) est obtenu à partir d'embryons zygotiques disséqués de grines entreposées pendant 3 à 11 ans. Ils sont cultivés sur le milieu de Litvay, utilisé à la moitié de sa concentration, auquel est ajouté 10 µM d'acide 2,4-dichlorophénoxyacétique, 5 µM de BAP, 1 g/L d'hydrolysat de caséine, 500 mg/L de glutamine et 1% de saccharose. L'imbibition des grianes pendant 4 h et une température d'incubation de 25°C améliorent significativement la fréquence d'induction de cal embryogène. Le rendement en cal embryogène est significativement affecté par la provenance géographique des graines et par le nombre d'années d'entreposage. Une corrélation

significative est aussi démontrée entre le rendement en cal embryogène et le pourcentage de germination du lot de graines utilisé. Ainsi, même après 11 ans d'entreposage, 40% des embryons zygotiques peuvent produire de cal embryogène s'ils proviennent de graines avec un fort pourcentage de germination. On obtient des embryons somatiques après transfert du cal embryogène sur un milieu de développement composé du milieu de Litvay à demi-concentration incluant 6 % de saccharose, 1 µM d'acide 2,4-dichlorophénoxyacétique et 5 µM de kinétine. Les embryons somatiques germent *in vitro* avant d'être transplantés en sol. Les plantules obtenues, établies en serre, sont similaires aux plantules témoins obtenues par germination de graines. Les embryons zygotiques provenant de graines entreposées constituent une bonne source de matériel pour l'embryogenèse somatique chez l'épinette blanche.

199. Van Wagner, C.E. 1988. Effect of slope on fires spreading downhill. Can. J. For. Res. 18:818-820.

A laboratory experiment was performed to determine the effect of slope on the downhill spread rate of forest fire. Results with beds of pine needles showed that the spread rate decreased to 64% of the level rate as slope was raised to 22°, then gradually increased back to the level rate at 45°. Some theory about how the flame radiates to the unburned fuel was advanced to account for this phenomenon.

Une expérience en laboratoire a été effectuée pour déterminer les effets de la déclivité sur la vitesse de propagation d'un feu de forêt progressant vers le bas d'une pente. Les résultats du brûlage de lits d'aiguilles de pin montrent que la vitesse de propagation le long d'une pente s'abaissant à 22° diminuait à 64 % de la vitesse de propagation en terrain plat pour ensuite réaugmenter graduellement et redevenir indentique à la vitesse de propagation en terrain plat à 45°. Une théorie sur le mode de rayonnement de la flamme vers le combustible imbrûlé a été avancée pour expliquer ce phénomène.

200. Van Wagner, C.E. 1988. The historical pattern of annual burned area in Canada. For. Chron. 64:182-185.

The record of national annual burned area from 1918 to 1986 is smoothed and presented as three kinds of running averages: simple arithmetic means, exponential means, and binomial means. The main features of the whole sequence are 1) a gradually decreasing trend for the first few decades followed by a sharp rise in the 1970s and early 1980s, and 2) a subsidiary rise and fall at a fairly regular interval of about ten years. The chance that these patterns are just statistical accidents is very low. Climatic cycles or trends that affect the weather with respect to forest fire are the most likely cause. Whatever the reasons, the fires of the 1970s and early 1980s have quite upset the pre-1970 trend of decreasing national annual burned area.

Les données concernant les superficies détruites par le feu chaque année de 1918 à 1986 et compilées à l'échelle nationale sont lissées et présentées en trois modèles de moyenne mobile: moyenne arithmétique simple, moyenne exponentielle et moyenne binômiale. Les principales carctéristiques de cette série sont, tout d'abord, une tendance graduellement décroissante pendant les premières décennies, suivie d'une augmentation marquée dans les années 70 et début 80 et, ensuite, des augmentations et des baisses subsidiaires à des intervalles assez réguliers d'environ 10 ans. Il est peu probable que ces modèles ne soient que des accidents statistiques. Les cycles ou tendances climatiques qui influencent les conditions météorologiques en ce qui concerne les incendies de forêt en sont la cause la plus vraisemblable. Quelles qu'en soient les raisons, les incendies des années 70 et du début des années 80 ont complètement bouleversé la tendance d'avant 1970 qui montrait une décroissance des superficies détruites par le feu chaque année au pays.

201. Van Wagner, C.E. 1989. Prediction of crown fire in conifer stands. Pages 207-212 *in* MacIver, D.C., et al., eds. Proc. 10th Conf. Fire and Forest Meteorol., April 17-21, 1989, Ottawa.

A scheme is presented for dealing with the full range of fire behavior in conifer forests. It is based on empirical data from fires in Canadian forests plus a theory to describe the physical conditions for the transition from surface to crown fire. In its ideal form, the model consists of two distinct equations for spread rate in a given forest, one each for surface and crown fire, plus the rules for the transition upward or downward between them. For lack of enough data in some cases, a compromise has been devised that distinguishes between surface and crown fires, but does not provide for complete separation of the spread-rate functions. The scheme will form part of the forthcoming Canadian Forest Fire Behavior Prediction (FBP) system.

Nous vous présentons une méthode pour faire face à toute la gamme de comportement du feu dans des forêts de conifères. Elle repose sur des données empiriques compilées lors d'incendies forestiers survenus au Canada ainsi que sur une théorie décrivant les conditions physiques de la transition entre un feu de surface et un feu de cime. Le modèle, dans sa forme idéale, comporte deux équations distinctes sur la vitesse de propagation dans une forêt donnée, l'une pour un feu de surface et l'autre pour un feu de cime ainsi que les règles pour calculer la transition entre eux vers le haut ou vers la bas. Compte tenu de l'insuffisance de données dans certain cas, nous avons trouvé une solution intermédiaire qui établit une distinction entre le feu de surface et le feu de cime, mais qui ne permet pas une séparation totale des fonctions de vitesse de propagation. La méthode fera partie de la Méthode canadienne de prévision du comportement des incendies de forêts qui va bientôt être rendue publique.

202. Van Wagner, C.E. 1990. Six decades of forest fire science in Canada. For. Chron. 66:133-137.

This account of the history and accomplishments of forest fire research in Canada begins with a few basic statistics and some background on changing attitudes to fire. An historical note on the contributions of Wright and Beall in the 1930s and 1940s follows. Fire science is then divided into six diverse categories: fire behavior, fire management systems, fire ecology, prescribed fire, fire economics, and fire suppression, with a note on developments and accomplishments in each. The references given are examples of the wide range of activity within the whole field of fire-related science and technology, but do not constitute a bibliography.

Cet article est un compte rendu de l'histoire et des réalisations dans les champs de recherche sur les feux de forêt au Canada. Le début est illustré de quelques statistiques et d'éléments de changement d'attitude à l'égard de l'incendie. Dans la partie suivante est décrite la contribution apportée à ces recherches par Wright et Beall dans les années 30 et 40. Depuis lors, les études scientifiques sur l'incendie se sont divisées en six catégories : comportement du feu, systèmes de gestion des incendies, pyro-écologie, brûlage contrôlé, économie relative aux incendies, extinction d'incendie. Des notes sur l'évolution de chacune ainsi que sur les accomplissements sont incluses dans la description. Les références sont des exemples d'une vaste gamme d'activités dans le cadre de la science et technologie de l'incendie sans constituer cependant une bibliographie.

203. Wagner, D.B.; Govindaraju, D.R.; Yeatman, C.W.; Pitel, J.A. 1989. Paternal chloroplast DNA inheritance in a diallel cross of jack pine (*Pinus banksiana* Lamb.). J. Hered. 80:483-485.

The inheritance of chloroplast (cp) DNA in jack pine was studied in the parents and progeny of a 4 x 4 complete diallel. Ninety-six percent of the progeny provided evidence of paternal inheritance, while the remaining 4% had cpDNA fragments that were absent in the parent(s) of the respective crosses/selfs. Isoenzyme analyses suggested that the majority of the nonparental progeny were the

result of pollen or other sources of contamination. The authors conclude that cpDNA is predominantly paternally inherited in jack pine independent of background genotype or direction of cross.

204. Wang, B.S.P. 1988. Review of new developments in tree seeds. Seed Sci. Technol. 16:215-225.

This paper reviews and discusses recent developments in the production, collection, processing, testing, and storage of tree and shrub seeds. The newly perfected net retrieval system for collecting genetically improved seeds from seed orchards represents a significant change from the conventional manual cone picking to completely mechanized seed collection. In seed production, handling, and evaluation of seed quality, more information on tropical and subtropical tree seeds has become available. To improve seed quality assessment for precision sowing in containerized seedling production, an x-radiographic technique for evaluating ungerminated seeds at the end of germination tests has been developed. In seed storage research, results have shown that some orthodox seeds of *Pinus* species can be safely stored for 50 years in sealed containers at above freezing temperature. It is very likely that the storage life of such seeds can be further extended by cryopreservation.

Cet article passe en revue et discute les nouveautés dans la production, la récolte, le traitement, l'analyse et la conservation des semences d'arbres et d'arbustes. Le système de récolte avec un filet qui a été récemment perfectionné pour la collecte de semences génétiquement améliorées dans les vergers à graines, represente une amélioration significative, depuis le prélèvement manuel conventionnel des cônes, pour la mécanisation complète de la récolte. Dans les domaines de la production, de la manutention et de l'évaluation de la qualité, plus d'informations sur les semences d'arbres tropicaux et sub-tropicaux ont été apportées. Pour améliorer l'appréciation de la qualité des semences en vue de semis de précision destinés à la production de plants en conteneurs, une technique radiographique a été mise au point pour évaluer les semences non germées à la fin des tests de germination. Concernant les recherches sur la conservation, des résultats ont montré que certaines semences orthodoxes d'espèces de *Pinus* peuvent être conservées sans dommage pendant 50 ans dans des conteneurs scellés, à des températures non gelantes. Il est vraisemblable que la durée de conservation de telles semences pourrait être encore plus prolongée par cryoconservation.

205. Wang, B.S.P.; Fogal, W.H.; Schooley, H.O. 1989. National Tree Seed Centre 1987-89, Petawawa National Forestry Institute. Pages 81-84 *in* Magnussen, S.; Boyle, T.J.B., eds. Proc. 22nd Meeting CTIA Part I, Edmonton, Alta.

The National Tree Seed Centre continues to provide international, national, and regional leadership in research, development, and services. A substantial amount of time has been spent by project personnel giving leadership to seed projects in Southeast Asia and Africa.

206. Ward, C. 1990. Preservation of black spruce clones through tissue culture. Pages 46-55 *in* Rogers, D.L., ed. 1990. Proc. Ann. Meeting, Black spruce clonal forestry program. OMNR, Timmins, Ont.

The production of somatic embryogenic callus is a recent breakthrough in the tissue culture of conifers. The demonstration that this material can be readily preserved in liquid nitrogen provides a method which may help solve some problems of conventional clonal forestry.

Somatic embryogenesis and cryopreservation of black spruce, *Picea mariana* (Mill.) B.S.P., were carried out at the Petawawa National Forestry Institute (PNFI) as a cooperative project between PNFI and the Northern Forest Development Group, OMNR.

207. Weber, M.G. 1988. Fire and ecosystem dynamics in eastern Canadian *Pinus banksiana* forests. Pages 93-105 *in* Verhoeven, J.T.A. et al., eds. Vegetation structure in relation to carbon and nutrient economy. SPB Academic Publ., The Hague.

Jack pine (*Pinus banksiana*) is an economically important Canadian tree species and its autecology is inextricably linked to fire. It would disappear as a natural component of the boreal forest landscape were it not for the periodic occurrence of fire. By examining a series of experimental prescribed burns, as well as wildfires, the dynamic interaction of jack pine ecosystems with fire was quantified. During the regeneration step, high frontal fire intensities of around 17 000 $kW \cdot m^{-1}$ are required to produce seedling numbers of 30 000 to 50 000 ha^{-1} which are considered adequate for establishing the next generation of crop trees. Seedling height was also a function of frontal fire intensity with best growth performance exhibited by those sites exposed to greatest fire intensity.

Functional ecosystem attributes, such as soil respiration (CO_2 evolution), decomposition (assessed by using litterbags), litterfall, and nutrient and organic matter turnover rates were also measured. All lines of evidence pointed to jack pine ecosystem stability in its interaction with fire, i.e., periodic fires resulted in only temporary deviation from steady state conditions. Exceptions to this pattern were observed when fire reoccurred within 15 years of stand establishment or when forest floor layers were mechanically disturbed in mature stands.

208. Weber, M.G. 1990. Forest soil respiration after cutting and burning in immature aspen ecosystems. For. Ecol. Manage. 31:1-14.

Soil respiration was estimated in immature aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx.) ecosystems of eastern Ontario subjected to cutting and burning treatments in relation to vernal leaf flush. Soil respiration was measured as CO_2 evolved *in situ* using soda lime.

Respiration levels varied seasonally from a midsummer high of around 7000 mg CO_2 m^{-2} day^{-1} to spring and autumn lows of slightly over 2000 mg CO_2 $m^{-2}day^{-1}$. Cut and burned plots showed temporary declines in CO_2 evolution rates for two growing-seasons compared with an untreated control. During the third growing-season, respiration rates had fully recovered to pre-treatment levels.

Soil surface temperatures, soil moisture-content, and rainfall were monitored on all treatments. Cutting and burning treatments resulted in elevated maximum soil temperatures and reduced soil moisture contents. Interactions of environmental variables with respiration patterns were examined through correlation analysis. Maximum soil surface temperature and soil moisture content proved to be the most reliable predictors of CO_2 evolution on all treatments.

209. Weber, M.G. 1990. Response of immature aspen ecosystems to cutting and burning in relation to vernal leaf-flush. For. Ecol. Manage. 31:15-33.

Vegetative reproduction, aboveground biomass and nutrient pools, and litterfall and substrate nutrient conditions were evaluated in eastern Ontario immature (age 20 years) aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx.) ecosystems that had been subjected to the following four treatments in relation to vernal leaf flushing: burning before; burning after; cutting before; and cutting after flushing. An untreated control area was set aside for appropriate comparisons.

Three years after treatment, the greatest numbers of stems ha^{-1} were supported by the pre-flush cutting treatment (1100 stems ha^{-1}) followed in decreasing order by post-flush cut (9000), post-flush burn (4000), and pre-flush burn (2000). No suckering was observed on control plots. Above-ground aspen

biomass and nutrient-pool values reflected stem densities and these results were discussed in light of known physiological responses of the species to disturbance.

Litterfall mass and nutrient inputs over the 3-year observation period were also a function of treatment and reflected stand breakup. There was reduced suckering on the two burning treatments compared with more-vigorous suckering on the cuts. Thus, 3-year totals for litterfall mass (kg ha^{-1}) were: 29 470, 21 393, 10 182, 3022, and 1762 on post-flush burn, pre-flush burn, control, pre-flush cut, and post-flush cut, respectively. High litterfall biomass values on the burning treatments were a result of overstorey mortality, which reached 100% after three years. Nutrient returns through litterfall followed litterfall biomass input trends.

Forest floor and mineral soil nutrient pools on the burns showed treatment effects one month after burning which were interpreted in terms of removal of part of the forest floor, changed N-mineralization rates, cation leaching from ash, and differences in nutrient uptake patterns by surviving overstorey. After three years some treatment effects were still noticeable in forest floor and, to a lesser extent, in mineral soil nutrient pools.

210. Weber, M.G. 1990. Selected ecosystem processes in a *Pinus resinosa* Ait. forest in relation to other fire-affected eastern North American forest ecosystems. Fire in Ecosystem Dynamics, Pages 173-156 *in* J.G. Goldammer and M.J. Jenkins, Proc. Third Internat. Symp. on Fire Ecology, Freiburg, FRG, May 1989. The Hague, The Netherlands.

Litterfall, decomposition, organic matter turnover, and forest soil respiration (CO_2 evolution) in a mature (75 yrs) eastern Ontario red pine (*Pinus resinosa* Ait.) ecosystem were compared with similar eastern North American fire-affected forest types. Litterfall patterns were shown to be variable seasonably as well as from year to year. Annual litermass inputs varied from a high of 5300 $kg \cdot ha^{-1}$ to a low of 2400 $kg \cdot ha^{-1}$ during the three-year observation period. Nutrient inputs through litterfall followed mass input patterns. Understorey litter decomposed more readily than overstorey litter (needles) probably because of the higher nutrient content in understorey material, pointing to the importance of the understorey in overall nutrient cycling processes.

Organic matter turnover rates, or residence time, were between 19 and 16 years for the three red pine stand studied. This represents intermediate values between rapid rates such as 2 to 3 years for south central Wisconsin forests and relatively slow rates such as 43 years for jack pine (*Pinus banksiana* Lamb.) ecosystems in northern New Brunswick. Strong climatic control over ecosystem processes, as well as substrate quality, is implicated in the observed variability among forest types. It is apparent that climatic controls will assume added importance in studies of ecosystem structure and function in light of anticipated global greenhouse warming.

Soil respiration was measured *in situ* with soda lime and shown to be very similar to levels observed in adjacent jack pine forests. Seasonal respiration means in red and jack pine forests with various fire histories were around 4300 mg of $CO_2 \cdot m^{-2} \cdot d^{-1}$. In comparison, local fire-origin aspen stands had soil respiration rates in excess of 5000 mg $CO_2 \cdot m^{-2} \cdot d^{-1}$, reflecting better nutritional status of the aspen site. Temperature appeared to be the overriding controlling factor in determining substrate respiration patterns. Soil moisture content and rainfall proved to be poor predictors of respiration activities in this study.

211. Whynot, T.W.; Penner, M. 1990. Growth and yield of black spruce ecosystems in the Ontario Clay Belt: Implications for forest management. PI-X-99.

Fifty years of permanent sample plot growth information from the Clay Belt Region of Northern Ontario were analyzed. Operational groups (OG's) defined by the Forest Ecosystem Classification (FEC) system for the Clay Belt were compared on the basis of productivity (black spruce (*Picea*

mariana [Mill.] B.S.P.) site index at age 50) and grouped into broad productivity classes. An alternate approach, comparing the OG's on the basis of their site index curve shape, did not appear to be an improvement over the first method and was not pursued. The advantages of using the FEC system for forest productivity studies are that it is an objective classification scheme and is used for silvicultural decision making. The disadvantage is that the system is not based on forest productivity and may not be the best classification for growth and yield predictions.

Local black spruce volume tables and stand volume curves were developed based on these classes. Productivity class I volumes peaked earlier and declined at a younger age than other classes and preliminary results indicate volume decline is strongly related to black spruce top height. Mixed stands generally produced slightly more volume than pure black spruce stands on similar sites.

A comparison of cut-origin versus fire-origin stands revealed that post-harvest stands have substantially lower black spruce but higher balsam fir (*Abies balsamea* [L.] Mill.) volumes, indicating that volume curves developed for old growth stands are not suitable for cut stands. Examination of two noncommercially thinned old growth stands at age 80 (approximately 40 years after treatment) revealed no measurable benefit from thinning.

[*Unfortunately, computing errors in this publication have compromised the validity of the data presented. A revision of this work, with corrected data and additional analyses, will be published later.*]

On a analysé les renseignements qui ont été recueillis sur la croissance à des parcelles-échantillons permanentes dans la Zone d'argile de l'Ontario, pendant les derniers 50 ans. Des Groupes opérationnels (GO) définis par la Classification des écosystèmes forestiers (CEF) pour la Zone d'argile ont été comparés du point de vue de la productivité (épinette noire (*Picea mariana* [Mill.] B.S.P.), indice de station à l'âge de 50 ans) et réunis dans de grandes classes de productivité. Une deuxième approche, la comparaison des Groupes opérationnels en ce qui concerne les formes de courbes des indices de station, ne semblait pas meilleure que la première et elle a été interrompue. L'avantage du système de CEF, quant à la productivité forestière, est que la classification s'avère objective et elle est utilisée lors des prises de décision. L'inconvénient du système est qu'il ne se repose pas sur la productivité forestière elle-même et qu'il ne semble pas être la meilleure classification en matière de croissance et de possibilité.

Les tables de volume de l'épinette noire locale ainsi que les courbes de volume des peuplements ont été dressées en se fondant sur ces classes. Les volumes de la classe I de productivité ont atteint leur maximum plus tôt et décliné à un âge moins avancé que les autres classes. Les résultats préliminaires indiquent aussi que le déclin est étroitement lié à la hauteur dominanante de l'épinette noire. En général, les volumes des peuplements mixtes étaient légèrement plus élevés que les peuplements composés uniquement d'épinette noire, sur des sites similaires.

La comparaison entre les peuplements qui sont nés après une coupe et ceux qui sont nés après un incendie a révélé que les premiers comprenaient, de façon prononcée, des volumes moins élevés de l'épinette noire, mais des volumes plus élevés du sapin baumiers (*Abies balsamea* [L.] Mill.). Ce phénomème veut aussi indiquer que les courbes de volumes qui sont dressées pour les peuplements vièrges ne conviennent pas aux peuplements qui sont nés après une récolte. Deux études ont démontré que la coupe éclaircie effectuée dans un peuplement vièrge de 80 ans (40 ans après le traitement) ne donnait pas de gain mesurable.

[*Dû à des erreurs de calcul dans cette publication, la validité des données sont malheureusement compromises. Une version revue, accompagnée des données corrigées et d'une analyse, sera publiée ultérieurement.*]

212. Zsuffa, L.; Burgess, D. 1989. Development of high yielding willows for energy production by hybridization. Pages 145-149 *in* Hogan, E.N., ed. 1989. Proc. Seventh Canadian Bioenergy Seminar, April 24-26, 1989, National Research Council of Canada.

Willow clones that have proven superior for use in energy plantations are not available in Canada. However, several North American species show large potential. ENFOR is supporting genetic and breeding research aimed at the development of high yielding willow clones by selection and hybridization of native species showing the greatest potential.

The species under study are *Salix amygdaloides, S. bebbiana, S. discolor, S. eriocephala, S. exigua, S. lucida, S. pellita,* and *S. petiolaris*. They are found on a wide range of sites in Canada, including boreal sites.

Selections were made over the range of these species. Hybridization and species incompatibility studies, and studies of nutrient demand and biomass accumulation, were completed. Research activities now in progress focus on advanced generation crossings, inheritance patterns and isozyme linkages in species and interspecific hybrids, as well as further clonal selection and evaluation studies. The text illustrates some of the results to-date.

Les clones de saule qui sont supérieurs comme espèces de plantation énergétique ne sont pas disponibles au Canada. Toutefois, plusieurs espèces nord-américaines semblent très prometteuses à cet égard. On parraine, dans le cadre du programme ENFOR, des recherches sur les aspects génétiques et sur le croisement dans le but de mettre au point, par sélection et hybridation des espèces indigènes les plus prometteuses, des clones de saule à haut rendement. Les espèces étudiées sont: *Salix amygdaloides, S. bebbiana, S. discolor, S. eriocephala, S. exigua, S. lucida, S. pellita* et *S. petiolaris*. On trouve ces espèces dans plusieurs régions au Canada, y compris les régions boréales.

Les sélections ont été faites à partir de l'ensemble de ces espèces. On a réalisé des études d'hybridation et d'incompatibilité spécifique, ainsi que des études sur la demande en éléments nutritifs et sur leur accumulation dans la biomasse. Les recherches actuellement en cours portent sur la pollinisation croisée de pointe, les modes d'hérédité et les liaisons factorielles isozymiques chez les espèces et les hybrides interspécifiques et comprennent des études plus poussées de la sélection et de l'évaluation clonale. On décrit aussi certains des résultats obtenus jusqu'ici.

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